

COUNTY OF SAN MATEO

COUNTYWIDE TELECOMMUNICATIONS

STRATEGIC PLAN

INSTITUTE OF GOVERNMENTAL
STUDIES LIBRARY

OCT 17 1994

UNIVERSITY OF CALIFORNIA

MARCH 1994



The Warner Group

MANAGEMENT CONSULTANTS
WOODLAND HILLS, CALIFORNIA

 The Warner Group

COUNTY OF SAN MATEO

Mr. County Tender
Chief Information Officer
Division of Technology
County of San Mateo

Belmont City, California 94003

Dear Mr. Tender:

COUNTYWIDE TELECOMMUNICATIONS

STRATEGIC PLAN

MARCH 1994



The Warner Group

MANAGEMENT CONSULTANTS
WOODLAND HILLS, CALIFORNIA



Digitized by the Internet Archive
in 2025 with funding from
State of California and California State Library

<https://archive.org/details/C101745686>



The Warner Group

MANAGEMENT CONSULTANTS

5950 CANOGA AVENUE, SUITE 600
WOODLAND HILLS, CALIFORNIA 91367
(818) 710-8855 • FAX (818) 710-1467

March 25, 1994

Ms. Dorothy Yetter
Chief Information Officer
Director of Technology
County of San Mateo
590 Hamilton Street
Redwood City, California 94063

Dear Ms. Yetter:

We have completed our study to develop a Telecommunications Strategic Plan for the County of San Mateo Information Services Department. This report revision includes changes that were made to the Radio Systems section to further reflect Emergency Medical Services (EMS) needs as well as current updates on 800 MHz. The report contains our findings and recommendations which should enable the County to proceed with improving its systems and networks to meet long-term telecommunications requirements.

BACKGROUND

The Information Services Department provides Countywide support for voice, data, radio and microwave networks. The Information Services Department (ISD) employs approximately 120 personnel assigned to two operational divisions: Business Systems and Technology Services. These divisions are supported by the Administrative and Planning/Special Projects groups. Each division provides specialized services for installation, maintenance, support, and long-range planning of communications systems and networks.

In 1971, the County developed a comprehensive communications plan. This plan has been guiding County communications planning for the past twenty years. Concurrent with a change in key Information Services Department personnel, the County opted to conduct a complete review of all telecommunications systems as a first step in defining a detailed strategy for supporting the County's growing communications infrastructure. Recognizing the need to carefully plan for future systems, the County retained The Warner Group to assist in preparing a strategic plan for telecommunications services. The County anticipates that this planning process will incorporate information and underlying strategies contained in the Information Services Department Tactical Plan, the Current Environment Document and the Information Management Strategic Plan compiled in 1992.

STUDY OBJECTIVES

The objectives of the study were as follows:

1. Conduct a detailed needs assessment to define on an overall basis the present and future telecommunications requirements for the County of San Mateo.
2. Develop alternative telecommunications systems approaches, including modifications to existing equipment, data communications, integrated voice response systems, videoconferencing, 800 MHz trunking and cellular technologies.
3. Identify infrastructure and interconnect requirements to support emerging technologies and future systems planning.
4. Identify organizational and staffing requirements and specify functions which should be assumed by the Information Services Department.
5. Prepare an economic analysis of the one-time and recurring costs for the alternative approaches.
6. Prepare a formal Telecommunications Strategic Plan which will guide the County of San Mateo for the next five to seven years.

STUDY APPROACH

In performing this study, information was gathered and reviewed regarding the County's current telecommunications systems, staffing levels and County demographics. We interviewed Information Services Department management and staff to develop a thorough understanding of the current voice, data, microwave and radio networks and to discuss a strategic vision for ISD. We met with representatives of key user organizations to discuss systems usage and future business directions, and we developed and distributed a systems survey to gain information and feedback from departments not formally interviewed. Site visits to communications facilities were conducted to observe the operation and performance of each system, and County documentation of existing systems and networks was reviewed. Findings were documented and reviewed with the Steering Committee to validate and solicit feedback on the information gathered.

Information developed during the review of present systems was utilized to assess and document the County's needs and requirements in the areas of systems, infrastructure and organization. Needs and requirements were reviewed with the Steering Committee, and comments from this presentation were noted for inclusion in the Strategic Plan.

After evaluating the telecommunications needs and requirements, we began the analysis of alternatives. We reviewed and documented alternative approaches to meet the needs and to provide a foundation for emerging and future technologies. We then analyzed the practicality, costs and potential organizational and staffing impacts of the alternative approaches.

An overview of the alternatives analysis, together with a review of pertinent technologies, was presented to the ISD management team for initial review and comments. We then prepared the draft Telecommunications Strategic Plan which was reviewed with San Mateo County representatives.

SUMMARY OF RECOMMENDATIONS

The following is a summary of our key recommendations, which are described in greater detail in the body of the report:

- The County's telephone communications infrastructure utilizes SL-1 PBXs. As equipment fails, parts will become more difficult to locate and repair. The County should identify and document a phased replacement of the SL-1 hubs with new Meridian-1 architecture.
- The County currently utilizes three different voice mail architectures installed in five locations. Meridian Mail should be adopted as the Countywide voice mail standard, and a system design incorporating two centralized systems should be developed. Meridian Mail is fully compatible with the Meridian-1 PBX product line, including call center and integrated voice response applications.
- The County maintains disparate data communications backbones and minimal standards due to a lack of a comprehensive network plan. To provide support for all current and emerging technology requirements, the County should develop a detailed plan for the implementation of a new, high speed, protocol independent, enterprise network. The network should be driven by specific application requirements of departments and users. This network approach should support the County's migration to client/server computers.
- The existing radio system requires extensive maintenance due to the age of the system and the rigorous performance and reliability requirements of the public safety and EMS user environment. The County's radio infrastructure should be upgraded in a phased manner with components designed to operate within refarming specifications. Outdated mobile and portable radios should be replaced. This phased implementation should be coordinated with planning for regional communications systems upgrades.
- The Sheriff's Department utilizes voice radio for all field communications. A mobile data computer (MDC)/laptop system should be implemented on a standalone radio channel to provide CAD information and direct access to NCIC, CLETS, CAD and RMS for Sheriff's Department users.
- The County's common communications infrastructure consists of both analog and digital microwave systems. The analog system is the critical backbone for the simulcast radio system. It is not redundant and critical components are outdated. A single procurement should be conducted to

replace and enhance existing systems with new digital equipment. The digital microwave system primarily supports the voice and data systems and is substantially backed-up; however, some paths are equipped to capacity. To support increasing requirements for expanded voice, data, radio and video communications, both microwave systems should be upgraded. Paths should be equipped to support additional channels as determined through the network design process.

- Wire and cable distribution in the County is well-documented, but much of the installed base does not meet the Level V standard recently established by ISD for all new station wiring. The County should adopt as a wiring standard two, four-pair cables meeting end-to-end Level V specifications for all wire runs. Retrofits should be undertaken where necessary and feasible.
- The ISD management team has begun a shift in focus from being a technical service provider to simply providing project coordination and consultation. To accomplish this change in focus, ISD should adopt a functional model aligned with stated technology directions and develop a plan for departmental restructuring and retraining.

COST SUMMARY

Listed below is a summary of estimated one-time and annual recurring costs for each area of the Strategic Plan. These costs are presented in detail in the body of the report.

<u><i>Project Component</i></u>	<u><i>Estimated One-Time Costs</i></u>	<u><i>Estimated Annual Recurring Costs</i></u>
Voice Systems	\$5,339,000 - \$6,139,000	\$698,000 - \$884,000
Enterprise Data Network	1,051,000 - 1,673,000	105,000 - 167,000
Radio Systems	4,698,000 - 6,803,000	470,000 - 681,000
Infrastructure	3,184,000 - 4,374,000	191,000 - 263,000
<i>TOTAL</i>	<u><i>\$14,272,000 - \$18,989,000</i></u>	<u><i>\$1,464,000 - \$1,995,000</i></u>

Based on the recommended action plan, we have estimated the cost flow requirements over the first four years of the project. The estimated one-time costs applied to Year One should range from \$1,665,000 to \$2,770,000; Year Two should range

from \$6,175,000 to \$7,615,000; Year Three should range from \$4,776,000 to \$6,805,000; and Year Four would range from \$1,656,000 to \$1,799,000.

BENEFITS

We believe the County of San Mateo should derive significant benefits as a result of implementing the recommended solutions. Among the benefits to be realized are the following:

1. Upgrade to modular Meridian-1 architecture should ensure growth and enhancement while retaining some existing equipment and minimizing retraining efforts.
2. Adopting Meridian Mail as Countywide voice mail standard should establish a strategy for a common, centralized platform while fully utilizing existing systems until the coordinated implementation process is completed.
3. A high speed, protocol-independent enterprise network should enable the County to support current and evolving data communications technologies, while providing the flexible infrastructure needed to support client/server computing and advanced public access applications.
4. Migrating to client/server computing should utilize platforms and networks for their most efficient and effective purposes.
5. Development of standards should ensure network and equipment compatibility and provide flexibility and procedural guidance to the user community and ISD.
6. Upgrade of the simulcast radio backbone should enable the County to improve performance, coverage and quality of simulcast radio transmissions, while allowing for phasing of equipment acquisition. In this manner, future technology decisions may more readily incorporate emerging systems developments as well as accommodate changing FCC regulations.
7. Implementation of mobile data computing should reduce voice traffic on primary radio channels and should increase field user effectiveness and safety by enabling direct access to internal and external databases
8. The suggested microwave infrastructure configuration should provide expanded channel capacity to enable the County to increase system usage

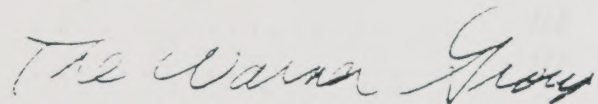
to accommodate emerging voice, data, radio and video requirements while providing hot-standby components to minimize the risk of equipment failure.

9. Standardizing on Level V cable should support all current and emerging voice and data equipment and transmission requirements.
10. The functional organizational model for ISD should identify critical areas of operation in the emerging technical infrastructure and establish a foundation for departmental realignment, streamlined work efforts and enhanced user interactions.
11. Phased implementation approaches for many system upgrades should minimize user disruption and facilitate project budgeting and financing.

* * * * *

We wish to thank you for the opportunity to provide management consulting services to the County of San Mateo. We look forward to continuing to work closely with you to complete this important project.

Very truly yours,



The Warner Group

COUNTY OF SAN MATEO

COUNTYWIDE TELECOMMUNICATIONS STRATEGIC PLAN

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
I. Introduction	I - 1
II. Voice Systems	II - 1
Overview of Current Systems	II - 1
Evaluation of Current Systems	II - 3
Needs and Requirements	II - 6
Alternatives Analysis	II - 8
Recommendations	II - 11
Estimated Costs	II - 11
Implementation Plan	II - 13
Benefits	II - 14
Exhibits	
III. Data Systems	III - 1
Data Systems	III - 1
Overview of Current Systems	III - 1
Evaluation of Current Systems	III - 4
Needs and Requirements	III - 6
Technology Overview	III - 9
Alternatives Analysis	III - 11
Recommendations	III - 15
Estimated Costs	III - 16
Implementation Plan	III - 17
Benefits	III - 17
Exhibits	
IV. Radio Systems	IV - 1
Overview of Current Systems	IV - 1
Evaluation of Current Systems	IV - 4
Needs and Requirements	IV - 6
Technology Overview	IV - 9
Alternatives Analysis	IV - 14
Recommendations	IV - 20

COUNTY OF SAN MATEO

COUNTYWIDE TELECOMMUNICATIONS STRATEGIC PLAN

TABLE OF CONTENTS

(Continued)

<u>SECTION</u>	<u>PAGE</u>
<i>Estimated Costs</i>	<i>IV - 22</i>
<i>Implementation Plan</i>	<i>IV - 23</i>
<i>Benefits</i>	<i>IV - 23</i>
<i>Exhibits</i>	
 V. <i>Infrastructure</i>	 <i>V - 1</i>
<i>Overview of Current Systems</i>	<i>V - 1</i>
<i>Evaluation of Current Systems</i>	<i>V - 3</i>
<i>Needs and Requirements</i>	<i>V - 5</i>
<i>Alternatives Analysis</i>	<i>V - 9</i>
<i>Recommendations</i>	<i>V - 14</i>
<i>Estimated Costs</i>	<i>V - 15</i>
<i>Implementation Plan</i>	<i>V - 16</i>
<i>Benefits</i>	<i>V - 17</i>
<i>Exhibits</i>	
 VI. <i>Organization</i>	 <i>VI - 1</i>
<i>Overview of Current Systems</i>	<i>VI - 1</i>
<i>Evaluation of Current Organization</i>	<i>VI - 1</i>
<i>Needs and Requirements</i>	<i>VI - 2</i>
<i>Alternatives Analysis</i>	<i>VI - 3</i>
<i>Recommendations</i>	<i>VI - 6</i>
<i>Benefits</i>	<i>VI - 7</i>
<i>Exhibits</i>	
 VII. <i>Action Plan</i>	 <i>VII - 1</i>

CONTENTS

SECTION I

INTRODUCTION

THE WARNER GROUP

I - INTRODUCTION

The County of San Mateo utilizes a combination of complex telecommunications facilities and systems to provide services to all County departments and several cities within the area. The County's Information Services Department manages the operation of voice and data communications systems, analog and digital microwave networks, and a countywide radio system. The development and implementation of these systems and their supporting networks was facilitated by the Information Services Department as part of a plan to provide a Countywide communications infrastructure. The Information Systems Department provides the maintenance and ongoing support for many of the existing systems and network components.

As a first step in developing the Telecommunications Strategic Plan for the Information Services Department, we conducted a detailed review of the present systems and operations. Included in our review was an assessment of the County's voice, data, radio and infrastructure systems. We also reviewed the supporting operations and organization. In addition, we estimated the deterioration rate and maintenance curve of the existing communications systems and equipment.

Next, we conducted a series of fact-finding interviews with department representatives to discuss future plans, priorities and high-level needs. Based on these interviews, the Needs and Requirements analysis identifies key elements, features and capabilities in each of the functional areas of the project: Voice, Data, Radio, Infrastructure and Organization. We also addressed future technology utilization within the County and identified the general systems, infrastructure and organizational enhancements which could be required to implement and support these new technologies. The requirements were developed and assigned priorities based on stated user priorities, County goals and objectives and system interdependencies.

As part of the needs and requirements analysis, we reviewed the County's service demand patterns and trends as well as population projections to determine their potential impact on the design of new communications systems. County population,

as documented in the 1990 census, was 649,623. Growth of approximately 5% to 683,000 is anticipated by 1995. By 2000, County population is expected to reach 717,000, an increase of slightly more than 10% over 1990 totals.

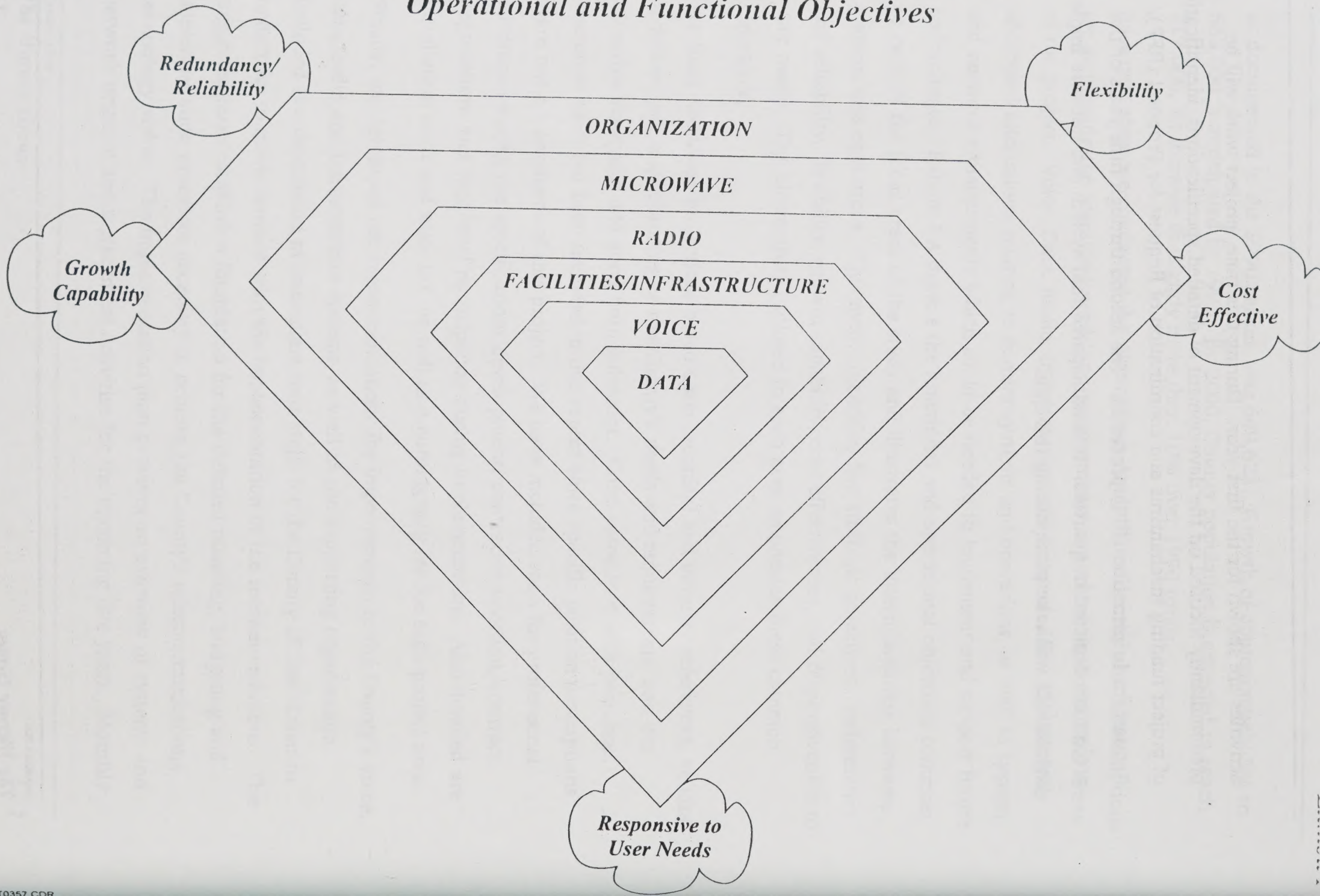
As a next step, we conducted the Alternatives Analysis to identify and assess options for addressing the identified needs and requirements in each of the functional areas of the project: Voice, Data, Radio, Infrastructure and Organization. The analysis addressed alternatives relating to current systems and operations, as well as system and network enhancements which could be needed to implement and support future technologies. Exhibit I-A depicts the functional and operational objectives common to each of the focus areas of the study and illustrates the interrelatedness between systems and operations. This model identifies five strategic objectives: redundancy and reliability, flexibility, growth capability, cost effectiveness, and responsiveness to user needs. The alternatives explored in each area emphasize these common objectives.

We then developed projections based upon technical and industry references, vendor inquiries, our understanding of the County's needs and requirements, and our objective viewpoint and good faith judgment. Costs associated with personnel resources have not been included in this report since specific position descriptions were not a component of this project. We have included costs for professional assistance during the specifications development, contractor selection, contract negotiations and high-level participation during implementation. Also detailed are installation costs and sales tax, as well as a contingency fee for each project area.

Finally, we developed our recommendations for improvements to the County's voice, data, radio and infrastructure systems, as well as the supporting organization. Included is a description of immediate next steps for the County of San Mateo to undertake to move forward with the implementation of the recommendations. The suggested tasks establish a foundation for the detailed planning, budgeting and implementation processes necessary to achieve the County's telecommunications technology vision. The implementation plan provides an overview of systems and network upgrade and replacement activities for the upcoming five years. Monthly

activities are shown for the first year. During this time, project work will be predominantly focused on the development of detailed specifications, identification of project funding mechanisms and coordination of Request for Proposal (RFP)/Request for Information (RFI) processes. The second through fifth years of the project are depicted in quarters. It is anticipated that system and network implementations will take place during this time.

COUNTY OF SAN MATEO
TELECOMMUNICATIONS STRATEGIC PLAN
Operational and Functional Objectives



SECTION II

VOICE SYSTEMS

THE WARNER GROUP

II - VOICE SYSTEMS

This section of our report contains our analysis of San Mateo County's voice communications and voice processing systems.

OVERVIEW OF CURRENT SYSTEMS

San Mateo County's voice communications network provides voice services to all County users. Voice communications are supplied and maintained through the Communications unit of the Information Services Department. The responsibilities of this unit include add, move and change activity, voice network management and system performance monitoring.

Voice Network Hubs

The voice communications network is composed of seven redundant Northern Telecom SL-1 switches and one Meridian-1 switch interconnected via landlines and digital microwave paths. The primary hub of the network is the SL-1 XT switch which was installed in 1980 and is located at the Redwood City facility. This switch has recently been upgraded, and is currently configured with high density circuit boards. The other seven SL-1s were installed in 1987 and 1988, concurrent with the implementation of a digital microwave system. The Meridian-1 switch was installed with the recent relocation of the Public Works Department. Most of the switches support multiple campus locations, as well as some off-premise extensions (OPXs) for remote key systems. Exhibit I-A depicts the San Mateo County voice communications system configuration.

Operator services for the County are located at San Mateo County General Hospital. Callers to the County's main listed numbers reach these operators. The network is partially engineered for direct inward dialing to enable direct access stations on the County system directly if the seven-digit number is known. Other users are accessed through centralized answering points.

Network routing and trunking arrangements are configured to provide cost efficiencies as well as some level of standalone functionality. Zone and long distance toll charges are minimized by utilizing the network routing capabilities of the SL-1 and Meridian-1 to deliver calls off the network from the closest switch to the destination rather than from the serving switch of the call originator. While such routing patterns maximize network utilization, direct in and out trunks installed on most of the County's nodes provide a means of standalone operation in the event of a network disruption. Exhibit I-B outlines the station and trunk quantities and capacities for the Northern Telecom hubs installed in San Mateo County.

The Redwood City and San Mateo County General Hospital SL-1s are configured with 12-hour battery backup and generator support. The remaining switches are configured with two to four hours of battery backup.

Voice Processing

The San Mateo County voice communications network includes five voice mail systems and one integrated voice response system. Octel Aspen voice mail systems, which each have a current capacity of 400 users and maximum expansion capacity of 3,000 users, are interfaced to the Redwood City and Harbor SL-1s. An Octel Branch voice mail system, with a maximum expansion capacity of 500 users, is interfaced to the Huntington switch. All three Octel systems were partially funded through a State program approximately five years ago and are dedicated to Human Services applications.

The San Mateo County General Hospital SL-1 supports a Digital Sound Voice Server system, which provides voice mail and automated attendant capabilities. The Voice Server, which was recently installed, is a product designed for central office use and can be configured to support a maximum of 20,000 users. The Meridian Mail system was installed on the Redwood City switch approximately six years ago. The Digital Sound and Meridian Mail voice mail systems are generally used by individuals whose extensions reside on the Redwood City and Hospital SL-1s, rather than being dedicated for specific departmental use.

Integrated voice response technology is utilized by the Municipal Courts for traffic-related functions. The SIMPACT integrated voice response system is interfaced to the Redwood City SL-1 and to the County mainframe via a SUN server connected to the Information Services Department Token Ring backbone.

EVALUATION OF CURRENT SYSTEMS

The following are our findings relating to the voice communications network and voice processing systems:

Voice Network Hubs

- *Voice Network is Aging* - Although the existing voice communications network has proven to be reliable, most of the major switch components are approximately six years old and reaching the end of their useful life. The general life expectancy of this type of equipment is in the six to eight year range. As equipment does fail, parts will become more difficult to locate and repair. For example, the SL1 telephone sets are no longer available as new equipment. As a result, increased repair work will be required to keep the system fully operational. In addition, the voice communications network will continue to degrade, resulting in unreliable voice communications throughout the County.
- *Switch Upgrade Plan has not been Documented* - As a result of the current system degradation, the Redwood City switch, which is the oldest of the SL-1s, has been upgraded with a new front-end processor, memory and quad-density shelves. The other SL-1s, which are approximately six years old, have not been upgraded. While plans for some upgrades and enhancements have been developed in conjunction with specific departmental remodeling and relocation projects, no Countywide plan for voice communications equipment upgrades has been documented.
- *Most Switches have Sufficient Growth Capacity* - With the exception of the Huntington switch, the San Mateo County SL-1s have adequate trunk and station line capacities to accommodate any growth likely to occur in the near future. It should be noted that the configuration of any of the County's switches could be impacted by personnel moves and organizational restructuring.
- *Huntington Switch to be Replaced* - The Huntington SL-1 is scheduled for replacement in 1994 when the new Public Health facility in Daly City is completed. A switch from the Meridian-1 product line is planned, but the

specific option level and system configuration has not yet been determined.

- ***New Switch Planned for San Mateo County General Hospital*** - An extensive, five-year remodeling and expansion project is currently in progress at San Mateo County General Hospital. Included in this project is a total switch replacement, including station equipment. The specific Meridian-1 system to be implemented has not yet been selected.
- ***Some Sites Dependent On Redwood City SL-1*** - The East Palo Alto site, which is served directly off the Redwood City SL-1, and the Warren Street SL-1, which maintains minimal incoming and outgoing trunks, are dependent on the Redwood City switch for sustained voice communications. In the event of a network or equipment failure impacting Redwood City, voice communications at these sites would be significantly impacted for the duration of the outage.
- ***Switch Software Levels Vary*** - The level of software installed on the County's voice switches is not consistent. As a result, some features, such as multiple rollover lines and forwarding paths, are not available to all users.
- ***Network Routing is Well-Utilized*** - The current network routing plan provides for efficient utilization of network resources with no service impact to users. The Information Services Department Current Environment Document notes annual savings of \$500,000 as a result of network routing of zone and long distance calls.
- ***SL-1 and Digital Microwave Capabilities Limit OPX Requirements*** - By utilizing switch and microwave technologies to channelize tie lines for direct termination into the Redwood City SL-1, the requirement for costly OPX circuits to the East Palo Alto area has been minimized. Approximately 96 lines to East Palo Alto users are configured as SL-1 station lines.
- ***Adds, Moves and Changes Planning Difficult*** - The Telecommunications Services unit of the Information Services Department is responsible for all add, move and change orders. End users must contact this group to schedule such work activity. However, sufficient lead time is often not available to accommodate new requests in a planned manner.
- ***Fax Lines Routed Through Network*** - All County fax lines are installed as switch extensions. This strategy ensures savings on zone and long distance fax transmissions through utilization of network routing. Unlike fax machines, most modems are installed on separate lines to maintain data communications apart from the voice communications network.

- *Additional Users on the Network Possible* - The San Mateo County Libraries are interested in becoming users on the County's telephone and voice mail systems. Library management believes that becoming part of the County voice network would enhance communications capabilities among library locations and with the public. Inclusion of libraries could significantly impact the planning and configurations of the systems and network.
- *DID Numbers Limited* - There are approximately 150 direct inward dialing numbers assigned to the County and available to meet expansion and growth requirements. Given the desire for departments to further utilize DID numbers, expanded use will be limited. Additional new DID numbers from the telephone company may impact the system dialing plan.

Voice Processing

Voice mail and integrated voice response system findings include the following:

- *Meridian Mail Users Exceed System Capacity* - The Meridian Mail voice mail system has a capacity of 250 users. At the present time, however, approximately 400 mailboxes are assigned. As a result, users often are unable to access the system to leave or retrieve messages during times of peak usage. In addition, users are allocated very limited message storage capacity limiting the functionality of the system.
- *Some Voice Mail Users Express Frustration with System* - Many users of voice mail recognize the potential value of voice mail as a productivity-enhancing tool. However, the current Meridian Mail capacity issues and resulting user problems have left some individuals frustrated by perceived systemwide voice mail inadequacies.
- *Meridian Mail System Favored by Users and Technical Staff* - Despite the current issues relating to user capacity on the Meridian Mail system, the technical staff responsible for maintenance report few overall operational problems with the system. Ease of use and feature functionality were also cited as favorable system user qualities. In addition, users who have utilized the Octel and Meridian Mail systems favor Meridian Mail due to its ease of use and perceived superior feature functionality.
- *Digital Sound Maintenance Complex and Time-Consuming* - While most routine Octel and Meridian Mail maintenance is performed by County personnel, vendor visits are required for many similar functions on the Digital Sound system. Such changes often require the system to be taken out of service, thereby impacting users and callers.

- *Integrated Voice Response Improves Service* - The IVR system currently utilized by the Municipal Courts for traffic applications has been widely accepted by both departmental staff and the public. Staff report that the use of the system has significantly reduced telephone calls and counter traffic. As a result, the Municipal Courts Division hopes to expand its integrated voice response applications to include calendaring, citation payment and attorney access to databases.

NEEDS AND REQUIREMENTS

The Northern Telecom SL-1 and Meridian-1 telephone hubs installed at key sites throughout San Mateo County, although reaching the end of their expected useful life, generally function efficiently with few operational problems. Identified needs and requirements relating to voice communications are focused in the areas of standards and technology migration. Specific needs for expanded use of integrated and interfaced peripheral products, such as voice mail, automated attendant and integrated voice response are also described.

	<u><i>Priority</i></u>
1. Network hubs need to be based on fully supported hardware and software platforms	High
2. Aging network components need to be replaced	High
3. Reliable network hubs needed to meet current and future operational requirements	High
4. Network hubs need to fully integrate with distributive voice processing systems	High
5. Network hub and voice processing components need to be modular in design to meet expansion and growth requirements	High
6. Voice mail system standard needs to be established to facilitate interoperability and ease of use.	High

	<i>Priority</i>
7. More efficient utilization of voice mail system resources needed to provide voice mail system access to more County users.	High
8. Expansion or replacement of Meridian Mail voice mail system needed to alleviate system access and message retention problems caused by excessive mailbox assignments.	High
9. Backup trunking configurations needed to support East Palo Alto and the Warren Street SL-1 in the event of Redwood City network or equipment outages.	High
10. Continued effective utilization of network routing and channelized tie lines needed to minimize network costs.	High
11. Additional DID numbers needed to meet growth requirements	High
12. The feasibility of providing County voice communications services and voice mail access to County libraries needs to be assessed	Medium
13. Countywide standards for IVR systems and connectivity needed to facilitate planning processes for user departments.	Medium
14. Expanded use of integrated voice response technology needed to support user department downsizing and plans for improved public access to County information.	Medium
15. User training and guidelines needed to establish protocols for voice mail usage.	Medium
16. Structured add, move and change process needed to facilitate scheduling of work and responsiveness to user requirements.	Medium

- | | |
|--|--------|
| 17. Ability to support increased use of automated attendant capabilities needed to enable departments to efficiently disseminate frequently requested information and permit self-direction of calls through the use of automated menus. | Medium |
| 18. Replacement plan for KTS equipment and OPX sites needed to ensure compatibility with available system features and functionalities. | Low |

ALTERNATIVES ANALYSIS

Voice Network Hubs

Network hubs provide the foundation for a robust, reliable voice communications system throughout the County. The selection of an architecture for network hubs considers several factors: the product performance and flexibility; the ability of a particular system to integrate with other existing systems; its expansion capability; and the system migration path. Upon evaluating these considerations and examining the current voice communications systems configuration in San Mateo County, we determined that one approach offers unique advantages. We suggest that the County continue in the direction of replacing the existing Northern Telecom SL-1 Hubs with Meridian-1 architecture. While this approach is consistent with County plans, we further suggest the development and documentation of a detailed migration strategy to guide budget, schedule and implementation processes. Such plans should include key decisions presently pending, such as system options, processor size and instrumentation selections. System requirements and specifications should be detailed, and a competitive procurement among Northern Telecom providers should be considered to ensure that the County secures favorable pricing.

The most significant advantage offered by migrating from SL-1 to Meridian-1 switches is Northern Telecom's modular architecture, which ensures future growth capacity and the ability to integrate enhanced feature subsystems. The Meridian-1

This alternative offers the advantage of leveraging existing voice mail resources and providing a common voice mail platform throughout the County. Both the Octel and Digital Sound product lines interface effectively to most state-of-the-art communications systems and provide system expansion capability.

The primary disadvantage of this alternative is that no system centralization is provided. Neither system offers key features, such as the ability to erase a message prior to the end of that message, which are favored by County users. The Octel systems are five years old and, while still fully functional, are approaching the end of their life cycles. Because of this, they should not be utilized as the foundation for a future-oriented voice mail strategy. Also, maintenance of the Octel and Digital Sound products is reportedly costly, complex and time consuming. Annual Octel maintenance is approximately \$38,000. In addition, the Digital Sound system, which supports 500 users and two automated attendant applications, must be taken out of service for simple maintenance procedures such as date changes.

Adopt Meridian Mail as Countywide Voice Mail Standard - As an alternative to expanding either the Octel or Digital Sound systems, the County could adopt Meridian Mail as a voice mail standard for County users. Implementation of additional Meridian Mail systems could be phased, in conjunction with Meridian-1 network hub upgrades and installations, to coincide with the aging of the existing Octel systems. A phased implementation could allow the County to fully utilize the existing systems and avoid the need to budget for two voice mail systems at the same time.

This alternative is consistent with the County's plan to migrate to Meridian-1 architecture. Meridian-1 supports centralized Meridian Mail over the primary rate interface (PRI) or ISDN signalling link. As such, this alternative represents a fully integrated voice mail approach. In addition, many County users prefer the features and functionalities of Meridian Mail over Octel or Digital Sound.

The primary disadvantage of this approach is that disparate systems are maintained during the phased implementation process.

product line provides currently supported hardware and software platforms while maintaining backwards compatibility with the installed base of SL-1 equipment. Finally, Meridian-1 fully supports integrated, centralized Meridian Mail and Meridian Integrated Voice Response.

It is important to note that while this approach offers the County significant benefits, migrating to Meridian-1 architecture is likely to involve a complex phased implementation process. The estimated migration costs, exclusive of instrumentation and dependent upon the selected system option and configuration, are approximately \$360 to \$500 per station. Instrumentation costs are approximately \$150 to \$500 per station, depending on the type of phone selected and requirements for peripheral features such as speakerphone capability. Exclusive of the Public Works switch, which has already been upgraded, the County serves approximately 5,500 users, including OPX locations. Accordingly, the estimated base system migration costs, including instrumentation are \$4,956,000 to \$5,699,000.

Voice Processing

As the County expands its use of voice processing, systems integration, ease of use and administration, and maintenance costs will be ongoing considerations. Based on these factors, two primary alternatives were identified and evaluated:

- Install additional Octel system(s) or expand Digital Sound system to accommodate all voice mail needs
- Adopt Meridian Mail as the Countywide Voice Mail Standard

Install Additional Octel System(s) or Expand Digital Sound System to Accommodate All Voice Mail Needs - The County's voice communications network includes three Octel, one Digital Sound and one Meridian Mail voice mail system. The Octel systems have been installed for approximately five years, and the Digital Sound system was implemented last year. One approach to providing more voice mail boxes to County users is to install additional Octel systems to complement the existing configuration, or to expand the centralized Digital Sound system to accommodate new users.

The County has secured a proposal from PacTel Meridian Systems to replace the existing Meridian Mail system. The proposal includes PBX integration and reprogramming for the existing 400 users. The quoted capacity of the 24 port, 114 hour system is 1,300 to 1,650 users, although practical capacity could be less due to storage requirements. A second Meridian Mail system could be installed along with the Meridian-1 network hub planned for the San Mateo County General Hospital. The Hospital switch supports 96 tie lines and more than 80 direct-in trunks, which should ensure system access. In addition, locating a Meridian Mail at the Hospital could facilitate utilizing automated attendant capabilities in conjunction with voice mail. Assuming 1,300 to 1,650 users are served on each voice mail system, dual systems such as the one proposed would provide access for the 2,600 to 3,300 County personnel who could effectively utilize voice mail to enhance work efficiency. The estimated costs for two Meridian Mail systems ranges from \$382,000 to \$440,000.

RECOMMENDATIONS

Our recommendations for improving the County's voice communications systems are as follows:

Voice Network Hubs

1. ***Replace SL-1 Hubs With Meridian-1 Architecture*** - San Mateo County's current voice communications equipment and network configuration has been in place for approximately six years, and has functioned efficiently. Due to the age of these network hubs, we believe the County should identify a migration strategy for these switches to the new, Meridian 1 architecture. Exhibit IV-C provides an overview of the proposed voice communications network and configuration.
2. ***Pursue Phased Implementation Approach*** - A phased implementation process, coinciding with key County expansion projects, such as those being undertaken in South San Francisco and at the San Mateo County General Hospital, is recommended. As an interim measure, software on all existing systems should be upgraded to the same generic to facilitate the migration process.

3. *Establish Migration Plan* - The County has conceptually committed to a migration to Meridian-1 architecture. A detailed implementation plan should be developed to guide the process. The plan should encompass network priorities as well as facility upgrade projects.
4. *Document System Requirements* - While the architecture of the new network hubs has been determined, key decisions relating to system option levels, processor power, integration requirements and instrumentation are outstanding. These issues should be researched and included in a detailed systems specifications document. These specifications can be utilized as a basis for a competitive procurement of the Meridian-1 hubs.
5. *Expand Use of DID* - The County should expand the use of direct inward dialing numbers to meet departmental requirements. Additional numbers will be required from the phone company which will likely impact the County's numbering plan. This should be considered in the development of the migration plan.

Voice Processing

1. *Adopt Meridian Mail as Countywide Voice Mail Standard* - Consistent with the County's migration to Meridian-1 architecture for its network hubs, we recommend that Meridian Mail be adopted as the voice mail standard. Meridian Mail is fully compatible, with Northern Telecom's voice communications switching design, and is favored by County users and technical support personnel.
2. *Identify System Design* - The County has recently negotiated a contract with a local vendor to upgrade and enhance the existing Meridian Mail system. Before committing to this purchase, a Countywide voice mail design should be established to determine the total number of users requiring voice mail, how ISDN links will be configured and what switch upgrades may be required to accommodate Meridian Mail.
3. *Install Meridian Mail Concurrent with Meridian-1 Implementations* - Meridian Mail should be upgraded in Redwood City as soon as the system design is finalized. The implementation of the second Meridian Mail system should be phased to coincide with the Meridian-1 installation at that site. An overview of the network configuration is provided in Exhibit II-C.

ESTIMATED COSTS

Voice communications costs assume total system replacement, including existing digital instrumentation, of all existing SL-1 switches with Meridian-1 PBXs. The costs further assume that centralized Meridian Mail will be adopted as the County's voice mail standard. ISDN links are included to support centralized Meridian Mail. Information provided by PacTel Meridian Systems was used as a foundation for these cost estimates, and reportedly reflects pricing discounts which could be extended to the County. Costs were provided for the larger Redwood City and San Mateo County General Hospital locations and for a 500 user system. Based on this information, a per-line cost was developed for the smaller locations. The estimated one-time costs for the Meridian-1 network hub implementations are \$4,955,975 to \$5,699,372. These costs are detailed in Exhibit II-D.

Voice mail cost estimates are based on two, 24 port, 114 hour Meridian Mail systems to meet the County's stated requirement of approximately 3,000 voice mail users. Voice mail cost estimates are based on a proposal provided by PacTel Meridian Systems, and account for recently anticipated cost increases. The estimated one-time Meridian Mail costs, which are detailed in Exhibit II-E, should range from \$383,348 to \$439,554.

We recognize that the County may elect to perform its own maintenance on the Meridian-1 and Meridian Mail voice mail systems. However, should vendor maintenance be desired, the estimated costs to support the Meridian-1 PBXs should range from \$314,830 to \$443,845. Meridian Mail maintenance costs should range from \$21,070 to \$24,154.

IMPLEMENTATION PLAN

The County should begin developing specifications for the upgrade to the Meridian network hubs and voice mail systems. Detailed specifications should then be issued to vendors with the intent of beginning implementations at the most critical sites within the first project year. Additional network hub upgrades and the voice mail

expansion should be completed at the end of the third year. The voice system implementation plan is shown in Exhibit II-F.

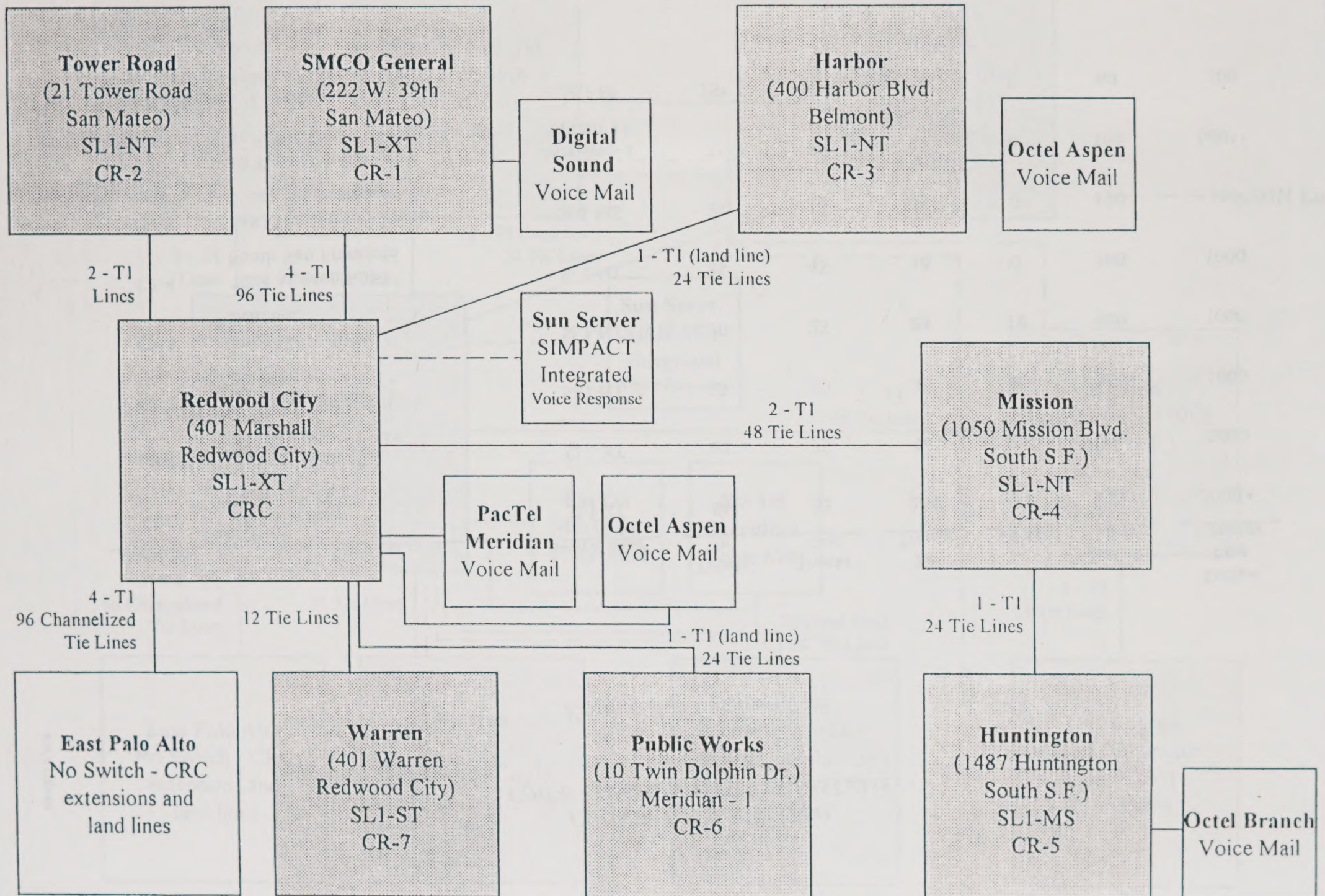
BENEFITS

We believe that significant benefits should be derived by San Mateo County as a result of implementing our recommendations. Some of these are listed as follows:

- The modular architecture of the Meridian-1 Network hubs ensures reliable growth and enhancement capability while potentially enabling the County to retain a portion of its original investment due to backward compatibility of systems.
- A phased implementation plan minimizes user disruption and may facilitate project budgeting and financing.
- Retraining efforts should be minimized due to user familiarity with basic Northern Telecom features, capabilities and instrumentation.
- Strategy provides common voice mail platform for all users and fully integrated systems.
- Enhanced capabilities of Meridian Mail could enhance business processes in user departments.
- System design and phased implementation should identify all integration requirement and fully utilize existing voice mail resources until integration occurs.

COUNTY OF SAN MATEO

Existing Voice Communications Systems Configuration



**COUNTY OF SAN MATEO
VOICE COMMUNICATIONS SYSTEMS**

Existing Hub Configurations

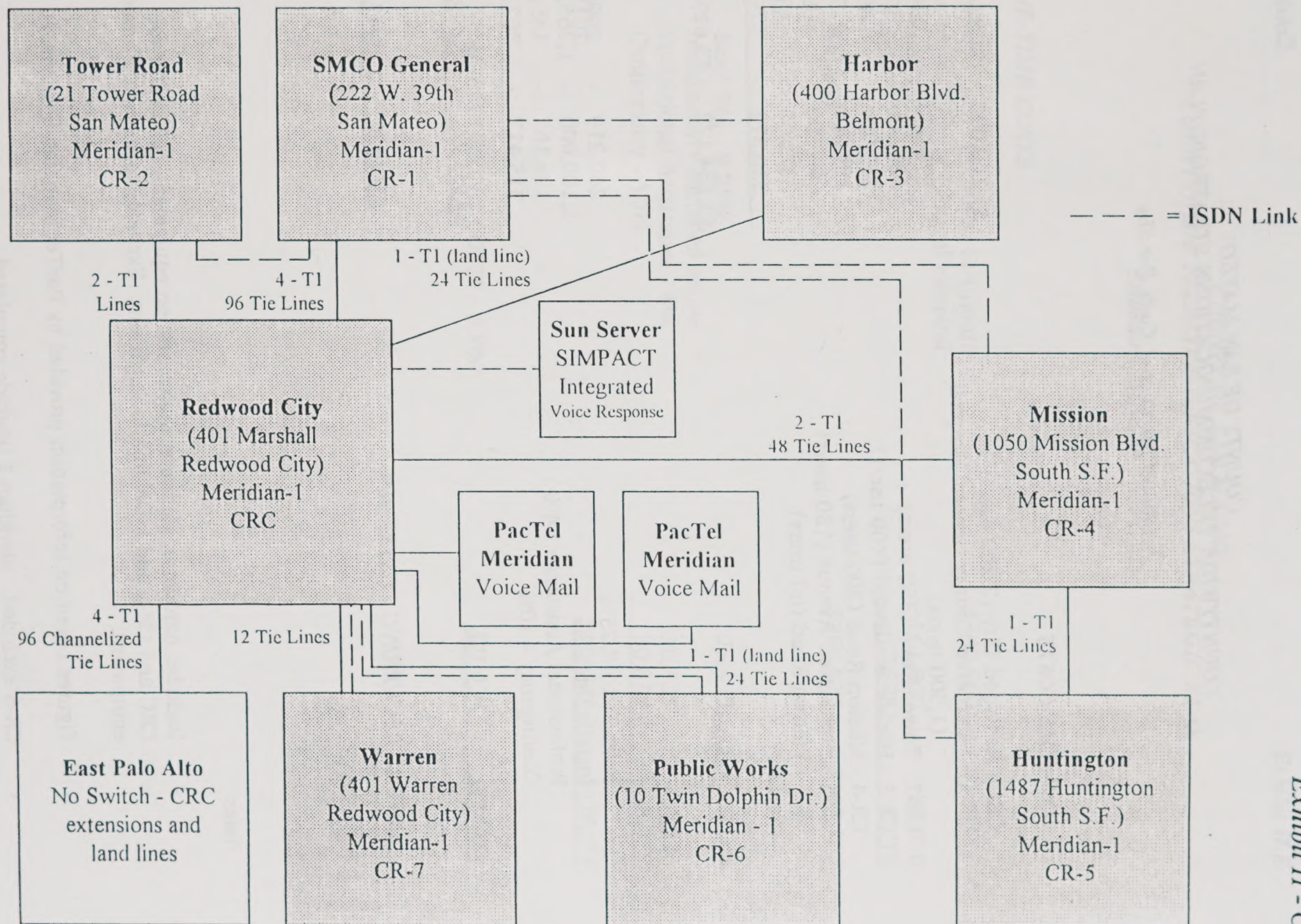
<u>Switch Identifier</u>	<u>Address</u>	<u>Switch Type</u>	<u>Trunks In</u>	<u>Trunks Out</u>	<u>Tie Trunks</u>	<u>OPXs</u>	<u>Station Lines</u>	<u>Station Line Capacity</u>
CRC	401 Marshall Redwood City	SL1-XT	86	85	264	410	2200	5000+
CR-1	222 W. 39th San Mateo	SL1-XT	82	75	96	109	1500	5000
CR-2	21 Tower Road San Mateo	SL1-NT	25	30	48	0	350	1000
CR-3	400 Harbor Blvd. Belmont	SL1-NT	30	25	24	18	400	1000
CR-4	1024 Mission Road South San Francisco	SL1-NT	25	45	48	0	300	1000
CR-5	1487 Huntington Avenue South San Francisco	SL1-MS	15	15	24	0	120	100
CR-6	10 Twin Dolphin Drive Redwood City	Meridian-1 Option 11	7*	7*	24	0	100	608**
CR-7	401 Warren Redwood City	SL1-M	15*	10*	10*	0	60	100

* Shared trunks

** up to 304 voice ports and 304 data ports

COUNTY OF SAN MATEO

Proposed Voice Communications Systems Configuration



COUNTY OF SAN MATEO
COUNTYWIDE TELECOMMUNICATIONS STRATEGIC PLAN

Estimated Meridian-1 Costs Per Site

ONE-TIME COSTS

CRC - Redwood City (2,200 users)	\$1,160,000	-	\$1,334,000
CR-1 - San Mateo County General Hospital (1,500 users)	870,000	-	1,000,500
CR-2 - Tower Road (350 users)	220,500	-	253,575
CR-3 - Harbor Boulevard (400 users)	252,000	-	289,800
CR-4 - Mission Road (300 users)	189,000	-	217,350
CR-5 - Huntington Avenue (150 users)	94,500	-	108,675
CR-7 - Warren Road (60 users)	37,800	-	43,470
Warranty	<u>330,372</u>	-	<u>379,928</u>

<i>Subtotal</i>	\$3,154,172	-	\$3,627,298
-----------------	-------------	---	-------------

Other

Sales Tax - 8.25%	260,219	-	299,252
Installation	1,100,000	-	1,265,000
Professional Assistance - 4%	126,167	-	145,092
Contingency - 10%	<u>315,417</u>	-	<u>362,730</u>

TOTAL	<u>\$4,955,975</u>	-	<u>\$5,699,372</u>
--------------	--------------------	---	--------------------

ANNUAL RECURRING COSTS - 10%	<u>\$314,830</u>	-	<u>\$443,845</u>
-------------------------------------	------------------	---	------------------

Notes:

- Includes hardware, software, digital station equipment, call center for CRC and CR-1 and ISDN link for each site. Excludes replacement analog equipment.
- Figures based on information provided by PacTel Meridian Systems.
- CR-6 excluded. Meridian-1 upgrade completed.

*COUNTY OF SAN MATEO
COUNTYWIDE TELECOMMUNICATIONS STRATEGIC PLAN*

Estimated Meridian Mail Costs

ONE-TIME COSTS

Redwood City: 24 ports, 114 hours	\$140,000	-	\$160,000
San Mateo County General Hospital: 24 ports; 114 hours	161,000	-	185,050
Warranty	7,578	-	8,715
<i>Subtotal</i>	\$308,578	-	\$353,765

Other

Sales Tax - 8.25%	25,457	-	29,186
Installation - included above	--	-	--
Professional Assistance - 6%	18,455	-	21,226
Contingency - 10%	30,858	-	35,377

<i>TOTAL</i>	<u>\$383,348</u>	-	<u>\$439,554</u>
--------------	------------------	---	------------------

<i>ANNUAL RECURRING COSTS - 5.5%</i>	<u>\$21,070</u>	-	<u>\$24,154</u>
--------------------------------------	-----------------	---	-----------------

COUNTY OF SAN MATEO
VOICE SYSTEMS
Implementation Plan

Exhibit II - F

	Year 1												Year 2				Year 3				Year 4				Year 5			
	1	2	3	4	5	6	7	8	9	10	11	12	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Meridian HUB Upgrades																												
Develop Migration Plan																												
Develop Specifications																												
Develop RFP/RFQ																												
Issue RFP/RFQ to Vendors																												
(Vendors Respond)																												
Evaluate Proposal(s)																												
Select System Components																												
Finalize Budget																												
Establish Project Timeline																												
Implement Systems																												
Voice Mail																												
Develop Migration Plan																												
Develop Specifications																												
Develop RFP/RFQ																												
Issue RFP/RFQ to Vendors																												
(Vendors Respond)																												
Evaluate Proposal(s)																												
Select System Components																												
Finalize Budget																												
Implement Redwood City System																												
Implement SMCO Hospital System																												

SECTION III

DATA SYSTEMS

THE WARNER GROUP

III - DATA SYSTEMS

DATA SYSTEMS

This section of our report contains our analysis of the San Mateo County's data communications network and systems.

OVERVIEW OF CURRENT SYSTEMS

The San Mateo County data network is comprised of numerous systems, architectures, protocols and applications. Two data processing centers house the majority of the installed systems. The Information Services Department operates the County Data Center located in Redwood City. The Health Services Department maintains its own data processing center and staff at San Mateo County General Hospital. The two organizations have minimal interaction; systems connectivity between the two data centers is limited to a single, one-way connection between the Health Services system and the County mainframe. In addition to systems supported through the County's two data centers, several departments maintain smaller systems for their own unique applications. Depending on departmental business requirements, these systems may be standalone or may be interfaced to the County mainframe.

The County mainframe is an IBM 3090 which supports in excess of 50 applications in most functional areas identified in the Information Management Strategic Plan. The 3090 interfaces to dual Ethernet and Token Ring backbones via a 3172 gateway. The mainframe configuration also includes a 3174 controller with a token ring interface card and dual 3745 terminal servers which provide SNA connectivity.

The County Manager's budget system resides on an IBM RS/6000. The budget application, which was selected through a joint RFP with Santa Clara County, is Unix-based. As a result, implementation of a Unix-based hardware platform to support the budget application was required. Due to budget system access require-

ments for all departmental fiscal officers, this hardware platform and application dictates dual backbones, multi-protocol access and the use of CISCO routers.

Public safety message switching for San Mateo County agencies is accomplished via a Digital Equipment Corporation (DEC) VAX 4000 and DEC 700 terminal server. The message switch provides access to databases such as CLETS, NCIC and DMV. The message switch and terminal server are connected to the network to enable database access by the Sheriff's office, Courts and related County agencies. A second VAX 4000 houses the PRC computer-aided dispatch (CAD) and management information system (MIS) software utilized by the County Public Safety Communications Center.

A Data General MV/4000 supports primarily Elections, Revenue Services, Public Works and Human Services applications. These systems are not installed on the County backbone.

Several IBM AS400s have been implemented by various departments throughout the County. The District Attorney's office, which formerly utilized three AS400s in its office and court locations, has recently consolidated its applications onto one B35 and F35 device. The remaining B35 is targeted for the County Recorder's Office. County Counsel and the Tax Collector/Treasurer's office each maintain an AS400 for their respective applications. These systems access the mainframe via 3745 terminal server connections. The Information Services Department does not directly support the AS400s, but does manage the systems' mainframe connectivity.

The Health Services Department utilizes and supports a network of DEC VAXes and terminal servers. Three Ethernet-interconnected VAX 8350s, one VAX 6410 and 23 terminal servers support local and remote devices for access to Health Services applications. Access from the Health Services Department network to the County mainframe is accomplished through an SNA gateway. No access to Health Services Department applications from the mainframe is provided.

The San Mateo County library system is housed on a GEAC minicomputer. Each branch location accesses the GEAC via a dedicated line. ISD does not develop

applications for the GEAC, which presently has no mainframe access, but does provide maintenance on the modems supporting the branch locations.

Additional standalone systems are referenced in the Information Management Strategic Plan. These platforms are not maintained by ISD. At least one user group, the Private Industry Council, anticipates replacing its Prime system with a local area network.

In addition to the mainframe and minicomputers maintained by the County's data center resources, numerous local area networks supporting administrative and specific departmental applications are installed throughout the County. While no specific LAN standards for equipment or protocols exist, most are Novell PC LANs with IBM PS2s or ASTs. Protocols utilized depend on host access requirements. Departments desiring local area networks may pursue such development and implementation projects through the Information Services Department, or may contract directly with an outside vendor. ISD involvement in LAN projects is required only for design of connectivity to County networks and applications.

The County's data backbone includes an Ethernet 802.3 local area network using IPX, TCP/IP and LAT protocols, and a 16 Mb token ring. The thick Ethernet extends from the fifth floor to the basement of the County Office Building, and routes to the eight floors of the adjacent Hall of Justice Building. The Token Ring supports the five floors of the County Office Building and extends to the annex. The two backbone components are joined by a CISCO router.

The old courthouse building is supported by 10 BaseT Ethernet connections via voice grade lines to the thick Ethernet installed throughout the Hall of Justice Building and County Office Building. Social Services maintains a 4 Mb token ring which connects to the Information Services Department backbone token ring via a 3174 controller with a token ring interface card and a 19.2 Kbps circuit. The Health Services Department maintains its own Ethernet to interconnect its VAXes. This network interfaces to the County's 802.3 Ethernet through an SNA gateway and dedicated circuit. Various local area networks, terminals and peripheral devices

access the County backbone through a combination of routers, gateways and servers. Communications facilities include house cable, leased lines, and T-1 circuits.

Exhibit III-A depicts the current systems and network configuration.

EVALUATION OF CURRENT SYSTEMS

Data communications systems findings are as follows:

- ***County Has No Comprehensive Network Plan*** - Network expansion and modifications may be driven more by specific departmental business requirements than by an identified strategy for network growth. While the approach effectively meets departmental needs, it could result in multiple costly changes to existing systems as well as potential future incompatibilities of network and system components.
- ***Disparate Backbones Maintained*** - The County maintains separate Ethernet and Token Ring backbones to support specific systems and applications. Maintaining dual backbones may be resource intensive and add complexity to future planning efforts for a seamless, fully integrated network.
- ***Reliance on Networking Technology Will Increase*** - The County Manager's stated priorities relating to technology implementation and utilization include greater use of LANs, development of imaging systems and applications, and improved public access to information. These objectives clearly will significantly increase the use of networking and related communications technologies in the County. In addition, the user community has a growing need for additional networking capabilities.
- ***No Standards for Mainframe Connectivity*** - ISD provides no published standards for providing connectivity to the mainframe. As a result, departments may select new applications packages based solely on user requirements without considering hardware and network implications.
- ***No Standards Exist for Local Area Network Implementations*** - Departments desiring LANs may contract with ISD, engage an outside vendor or complete the development and implementation in-house without regard to overall networking strategies within the County. This lack of implementation direction may hinder ISD efforts to develop equipment and network standards. Ongoing maintenance and support also becomes more difficult.
- ***Interconnect Capability Requires User Intervention*** - Users are currently provided the capability of accessing multiple systems and applications

from a single workstation. However, the requirement to navigate through multiple levels of networks can make the process cumbersome and result in slow response times.

- ***Approach to Equipment Maintenance Varies*** - Two options for equipment maintenance are provided. Departments may contact ISD or go directly to an outside source. ISD maintains contracts with several service providers and does some tracking of maintenance that they initiated.
- ***Many Leased Lines Utilized to Provide Connectivity*** - The data communications network services geographically dispersed users. As a result, the network includes many costly leased line services to accomplish the required connectivity.
- ***User Community Perceives ISD Mainframe Bias*** - A perception exists within the user community and some ISD units that the Information Services Department retains a bias toward mainframe solutions at the expense of other potential solutions. Some users cite a desire to work with ISD to develop new applications to meet changing business requirements, but increasingly prefer local area networks to the mainframe.
- ***User Community Believe Local Area Networking to be More Cost-Effective*** - Several departments, particularly those with skilled systems administrators, believe that significant cost savings can be generated by developing or purchasing local area network applications rather than utilizing the County mainframe. Recently instituted per device access charges were cited as a contributing factor to the higher cost of ISD services.
- ***New Library System Planned*** - PLAN, the local association of public libraries, is currently negotiating with Dynix to provide a new, Hewlett-Packard-based library circulation system to replace the current application residing on the GEAC minicomputer. Approximately 30 locations will be supported via dedicated lines. No immediate requirement for access to the mainframe is anticipated.
- ***Growth in Population Could Impact Network and Equipment Requirements*** - A population increase in the County of approximately 10 percent over 1990 levels is expected by 2000. The demands for County services generated by this increased population base, along with requirements to support emerging public access technologies, could impact system and network requirements.

NEEDS AND REQUIREMENTS

Data communications comprises a wide variety of systems, networks and procedures. As the County and ISD shift to a strategic focus on client/server, shared databases, open systems, imaging and public access, a comprehensive Countywide network plan is essential to establish a foundation for connectivity, access and application development. Many of the noted data communications needs and requirements relate to the development of standards and documentation of systems and procedures.

	<u>Priority</u>
1. High capacity protocol independent network backbone needed to provide the capability for any user at any workstation to connect to any system or application on the network.	High
2. Countywide plan for interconnection of facilities and networks needed as foundation for emerging technologies such as client/server.	High
3. Additional capacity needed to support new users and applications.	High
4. Transparent access to multiple systems and applications needed to facilitate user computing efforts.	High
5. Standards for mainframe connectivity and user equipment needed to ensure compatibility and provide flexible framework for selection and implementation of user equipment and applications.	High
6. Increased ISD focus on development of local area network and microcomputer applications needed to stay abreast of user requirements and expectations.	High
7. ISD participation in departmental application selections needed to coordinate requirements for new networks and supporting hardware.	High

- | | | |
|-----|---|--------|
| 8. | Local area network configuration standards and defined implementation process needed to facilitate network access, installation and support. | High |
| 9. | Detailed service level agreements need to be developed with each department to specify ISD services provided, equipment supported, response time guarantees and associated costs. | High |
| 10. | Increased utilization of network management tools needed to streamline testing and performance monitoring. | High |
| 11. | Standard approach to equipment acquisition and installation needed to ensure compatibility with existing and planned systems and networks. | High |
| 12. | Determination of ongoing role of mainframe needed to facilitate development of system, network and organizational strategies. | High |
| 13. | User participation in development of procedural standards needed to help ensure acceptance. | High |
| 14. | Clearly defined trouble reporting and escalation procedures needed to facilitate user requests for system support. | High |
| 15. | Value of networks and systems/applications planning process needs to be better understood by user departments to increase commitment to working with ISD. | High |
| 16. | Increased utilization of digital microwave system or SL-1s to provide data connectivity and reduce reliance on leased lines. | Medium |
| 17. | Countywide equipment maintenance contracts needed to facilitate monitoring of maintenance quality and costs. | Medium |

	<u>Priority</u>
18. Documentation of maintenance procedures, contacts and follow-up actions needed to facilitate tracking of maintenance requirements.	Medium
19. Defined strategy needed for County message switch connectivity.	Medium
20. Systems and network flexibility and joint planning needed to accommodate future Human Services requirements for access to Statewide automated systems, Health Services database and District Attorney's office.	Medium
21. Ability to support superset database, networked intake system and Countywide WAN needed to support structure envisioned by Human Services.	Medium
22. Flexible, secure system of remote network access needed to support expanding telecommuting requirements, remote work sites, decentralized delivery of service, and public access.	Medium
23. Continued development of business resumption plans needed to prepare user organizations to function efficiently in the event of long-term system failures.	Medium
24. Development of comprehensive document imaging guidelines needed to enable departments to proceed with projects utilizing this technology.	Medium
25. Expanded connectivity to other county systems needed to support evolving library system requirements.	Medium
26. Consistency of software revision levels needed among LANs to facilitate maintenance, support and documentation.	Medium

	<u>Priority</u>
27. Finalized, comprehensive change management process needed to provide procedural standards and checklists and minimize unanticipated service changes and disruptions.	Medium
28. Ongoing ISD training of departmental LAN administrators needed to develop support resources and effective working relationships.	Medium
29. Increased focus on quality assurance needed to help ensure reliability of systems and processes.	Medium
30. Accurate information needed to counter perception that departments can develop and manage systems and applications without involving ISD.	Medium
31. Defined strategy for Countywide geographic information system needed to guide GIS strategies for user departments.	Medium

TECHNOLOGY OVERVIEW

There are various evolving data communications technologies and standards being developed as a foundation for the next generation of networking to meet diverse, enterprise wide computing requirements. In this section of our report, we have included an overview of the various technologies that may affect the County's data communications systems over the next five to ten years. These issues were considered in developing our strategic recommendations.

FDDI - Presently, the 100 Mb Fiber Distributed Data Interface (FDDI) offers a relatively stable and readily available high capacity data communications option for transporting critical information and linking workgroups. FDDI networks incorporate counter-rotating rings which increase reliability by providing redundancy, since each ring backs up the other. Network access is accomplished via adapter cards installed in each user workstation. FDDI may be implemented as part of a network

incorporating intelligent hubs to provide transparent growth capability. While initially developed only for use over fiber-optic cable, FDDI-over-twisted-pair products began to emerge this year. As business requirements emerge or expand, new servers, routers and users can be added without disrupting existing service.

ATM - One of the evolving high-speed backbone network technologies is Asynchronous Transfer Mode (ATM). ATM uses fast-switching technology to offer extremely high speed data transmission in a connection-oriented format. Communications are accomplished by establishing a virtual channel between the sender and receiver(s) and then sending the information. A connection management system (CMS) evaluates possible paths and sets up network connections based on bandwidth requirements. In this manner, ATM offers highly managed bandwidth.

Fast Ethernet - A third high speed networking option currently being developed is Fast Ethernet, which promises to deliver 100 Mb of bandwidth to the desktop over unshielded twisted-pair wiring. While the objectives of Fast Ethernet have been defined, two proposals outlining access method, signalling and wiring requirements are competing for adoption as the standard. Fast Ethernet will reportedly cost less than FDDI and ATM technologies, but it is not expected to be standardized or available until at least 1995.

IBM/DCE - San Mateo County utilizes multiple vendor platforms, including IBM mainframe products. IBM is reportedly developing a client/server architecture which links data and applications from the largest mainframe to the smallest PC. Although this client/server strategy is still emerging, the approach embraces DCE (Distributed Computing Environment) specifications as a standard for binding distributed applications in a multivendor environment. DCE provides a standardized network interface for programming and communications, as well as an enterprise-wide directory and systemwide security. Connectivity which allows PCs to communicate, share network access and access mainframes and minicomputers is accomplished via the network operating system which functions as an overlay to the PCs' operating systems. IBM is currently developing and introducing numerous client/server

offerings, including network file servers, LAN management software, and a new relational database management system for OS/2.

ALTERNATIVES ANALYSIS

The data communications environment of San Mateo County must be structured to support evolving technologies and user requirements in a flexible, reliable and cost effective manner. Two primary data processing alternatives to meet these structural needs have been addressed.

- Maintain Current Mainframe/PC LAN Approach
- Migrate to Client/Server Environment

In addition, we have included an analysis of the enterprise network requirements and design to support the County's data processing approach.

Maintain Current Mainframe/PC LAN Approach - The County of San Mateo currently maintains a hybrid approach to data communications which utilizes mainframe and PC LAN systems and applications in a combination of centralized and local processing. In recent years, the focus of users' application development has begun to shift away from the mainframe in favor of local area networks. Mainframe connectivity through the local area networks is provided for access to Countywide applications such as budget programs. The County could continue to operate in this mode, supporting a mix of mainframe and local area network connectivity and continue to develop new mainframe applications as required.

This alternative retains the traditional ISD focus on mainframe application development and support, and maintains the current level of network complexity. Users, however, are migrating away from mainframe applications, due to cost savings and to real or perceived notions for more local control over applications and processes. In addition, ISD's stated technology direction is to migrate away from the development of mainframe applications to the client/server environment.

ISD currently has limited local area network support resources and is not adequately staffed to efficiently and effectively support this direction. To compound this issue, similar applications, such as word processing and spreadsheet functions are supported on multiple LANs. Finally, this hybrid approach, with diverse platforms and a lack of standardization, perpetuates a need for a resource intensive support structure.

Migrate to Client/Server Environment - As an alternative to maintaining a hybrid data communications structure comprising distinct mainframe and PC/LAN components and applications, the County could pursue its stated objective of migrating to a client/server environment. Under the client/server model, the individual user represents the client, and the server consists of multiple hardware, software and utility sources. Unlike a traditional computing environment which focuses on hardware and software, the client/server environment emphasizes the network, with each network node utilized for the most suitable tasks. In addition to utilizing each network node for the applications and processes most appropriate to the particular platform and configuration, client/server computing allows for sharing of work processing load among systems to provide maximum network efficiency. Through the use of a common file transfer protocol, user access to multiple applications is transparent.

One of the first steps to migrating to a client/server environment is to move toward "open standards" for computer hardware, software, applications and networking. Although open standards are still being developed, the industry is moving in the direction of open systems in areas such as workstation operating systems and network protocols. Several steps can be taken to position the County to benefit from open systems standards, including utilizing software tools that permit applications to be ported readily to mainframe, minicomputer or personal computer platforms. Additional steps include procuring applications that are less dependent on particular hardware platforms to facilitate moves from one platform to another as technology changes, and adopting a common graphical interface for all applications.

These approaches will require the County to effectively manage the distributed database systems.

The advantages of migrating to a client/server environment are numerous. Considered to be the industry focus for new technology, client/server offers simplified, relatively transparent user access to applications, as well as efficient utilization of network and system components through resource sharing. By maintaining a common network focus, flexibility to meet future computing needs is maximized.

Because client/server represents a transitioning technology, however, definitions, standards, and products are still emerging. Users are yet to be offered specifically detailed direction for selecting and implementing client/server technology. Since client/server computing focuses on the network and multiple hardware platforms for user applications, significant restructuring and retraining of the ISD support staff will be required as the County positions itself for a migration to this emerging technology.

Enterprise Network Approach

To effectively implement and utilize emerging computing strategies such as client/server and to ensure adequate network resources to support applications such as imaging, the County requires a flexible, dynamic, reliable and robust data backbone infrastructure. This network must offer protocol independence to allow any user to connect to any device or application. One way that the County can meet its long-term needs is by designing and installing a high speed enterprise network utilizing a mix of transport media based on applications and internetworking requirements.

The advantages to developing a high-speed, protocol independent networking approach relate to interoperability and reliability. By utilizing a network architecture such as FDDI which permits redundancy, the impact on County users in the event of a network failure could be mitigated. Users should experience transparent access to multiple platforms and applications, while employing varying amounts of network bandwidth as necessary to perform computing functions. Such a utility model of bandwidth on demand should offer the County the flexibility to meet

current and future computing requirements without frequent network redesign efforts.

While there are numerous advantages to the development of a high-speed, dynamic enterprise network approach, it will involve a complex and costly implementation approach. It also will require sophisticated network management tools and support capabilities. In addition, due to the current evolution of technology and new standards, the County will need to undertake a detailed design and evaluation process to ensure the appropriate decisions are being made.

A structured network design process should be undertaken to assess the needs for bandwidth, operating speed and connectivity at each major site based on applications requirements. The design process should include optimizing the performance of existing networks through development and implementation of standards and identification of skilled network support personnel. At those locations housing users whose current and future applications requirement dictate access to a high-speed network, a fiber-optic backbone should be considered. As a first step, a fiber backbone should be anticipated and designed for the Redwood City complex as an initial target for network development. This backbone should be configured to support operating speeds of up to 100 Mb.

This new Redwood City backbone should be linked with gateways to the existing 16 Mb Token Ring and 802.3 Ethernet networks. These existing networks should initially continue to be used to support user connectivity. Systems and applications should be migrated onto the new backbone as appropriate to meet County business and computing requirements.

Internetworking between key sites should utilize the digital microwave system. The microwave system should be able to support an additional eight T1s to meet the requirements for current and future bandwidths. If the applications assessment and resulting network design indicates a requirement for further channel capacity, the digital microwave paths could be equipped with additional channels up to 45 Mb. We recommend that the County begin assessing its current and planned applications

to determine anticipated campus and internetworking requirements. This applications assessment should be used as a foundation for developing a detailed network design and migration plan from which costs can be developed. For those sites which continue to be supported on leased facilities due to location, Pacific Bell's Advanced Digital Network (ADN) circuits should be considered. Providing full digital transmission, ADN circuits offer enhanced quality and reliability compared to traditional 3002 analog circuits.

While this approach offers maximum flexibility, a design process should be undertaken to identify detailed requirements, ensure proper functionality and guide decisions relating to network architecture and wiring topology. Although, without a detailed design, it is very difficult to estimate costs, we estimate that the cost to implement the first 200 users on the network, excluding application development, host interfaces and integration costs, to range from \$1,051,000 to \$1,673,000. The costs associated with the microwave component of the network are included in the microwave section.

RECOMMENDATIONS

Our recommendations for improving the County's data system are as follows:

1. *Pursue Migration Strategy to Client/Server Computing* - The County should begin formal planning for its intended migration to client/server computing. Relational database and hardware and software requirements should be analyzed. Existing systems should be evaluated to determine which current and planned processes are best suited for each system. The ongoing role of the County mainframe should be considered as migration strategy is developed.
2. *Develop Enterprise Network Design Based on Applications Assessment* - To provide support for all current and emerging technology requirements, the County should develop a detailed plan for the implementation of a new, high-speed, protocol-independent, enterprise network. The network should be driven by specific application requirements of departments and users. The network implementation should be coordinated with the migration to client/server computing. We recommend that this network strategy incorporate up to 100 Mb transmission rates utilizing mixed media. The network should support alternate routing and provide

transparent user access to multiple applications. The microwave network should be utilized to support required channel capacities between facilities. The proposed systems and network configuration are provided in Exhibit III-B.

3. *Focus on User Requirements* - The business requirements of each user organization should serve as the focus point in determining the appropriate platform for all new applications. Issues such as application access requirements, application size and complexity, processing needs, support requirements, security and costs should all be considered as platforms are evaluated.
4. *Develop Standards* - Standards in key areas of data communications should be developed, documented and disseminated where appropriate to the user community. Standards should address the following:
 - a. Mainframe connectivity requirements
 - b. Personal computer hardware and software
 - c. Application software
 - d. Local area network, hardware configurations, operating systems and protocols
 - e. Local area network procurement, implementation and support
 - f. Imaging
 - g. Maintenance and troubleshooting procedures
 - h. Equipment acquisition and installation
5. *Utilize Network Management Tools* - Increased utilization of network management tools should be incorporated into current operations to streamline testing and performance monitoring.

ESTIMATED COSTS

Cost estimates for the data communications backbone assume the installation of a fiber optic backbone at the County's eight PBX sites. Included in these cost estimates are the fiber backbone components, gateways to link the existing 16 Mb token ring and 802.3 Ethernet to the Redwood City fiber backbone, bridges and routers to link network segments, network software, and user interfaces for the initial 200 users to be migrated to the new backbone. Building wire and cable infrastructure costs are provided on a per run basis, and are also calculated to assume that the 200 selected for the initial migration to the new fiber backbone are not currently supported on Level V cable. The estimated costs to develop the enterprise network

for the first 200 users should range from \$1,050,700 to \$1,672,825. The cost detail is provided in Exhibit III-C.

We estimate that the annual recurring costs to maintain the suggested high-speed, protocol-independent network backbone should range from \$105,070 to \$167,283. This cost estimate includes components of the fiber backbone, as well as interfaces for the initial 200 users, but does not include maintenance of existing systems.

IMPLEMENTATION PLAN

The initial step towards the development of a new, high-speed enterprise data network is to develop a detailed network and configuration design, based on a detailed assessment of application requirements. Once the specifications and design of the data network are established, the County should issue an RFP to vendors with the intent to select a network vendor by the end of the first year. The implementation of the network should extend into years two through five as specific user needs are established and client/server applications are developed. The data systems implementation plan is shown in Exhibit III-D.

BENEFITS

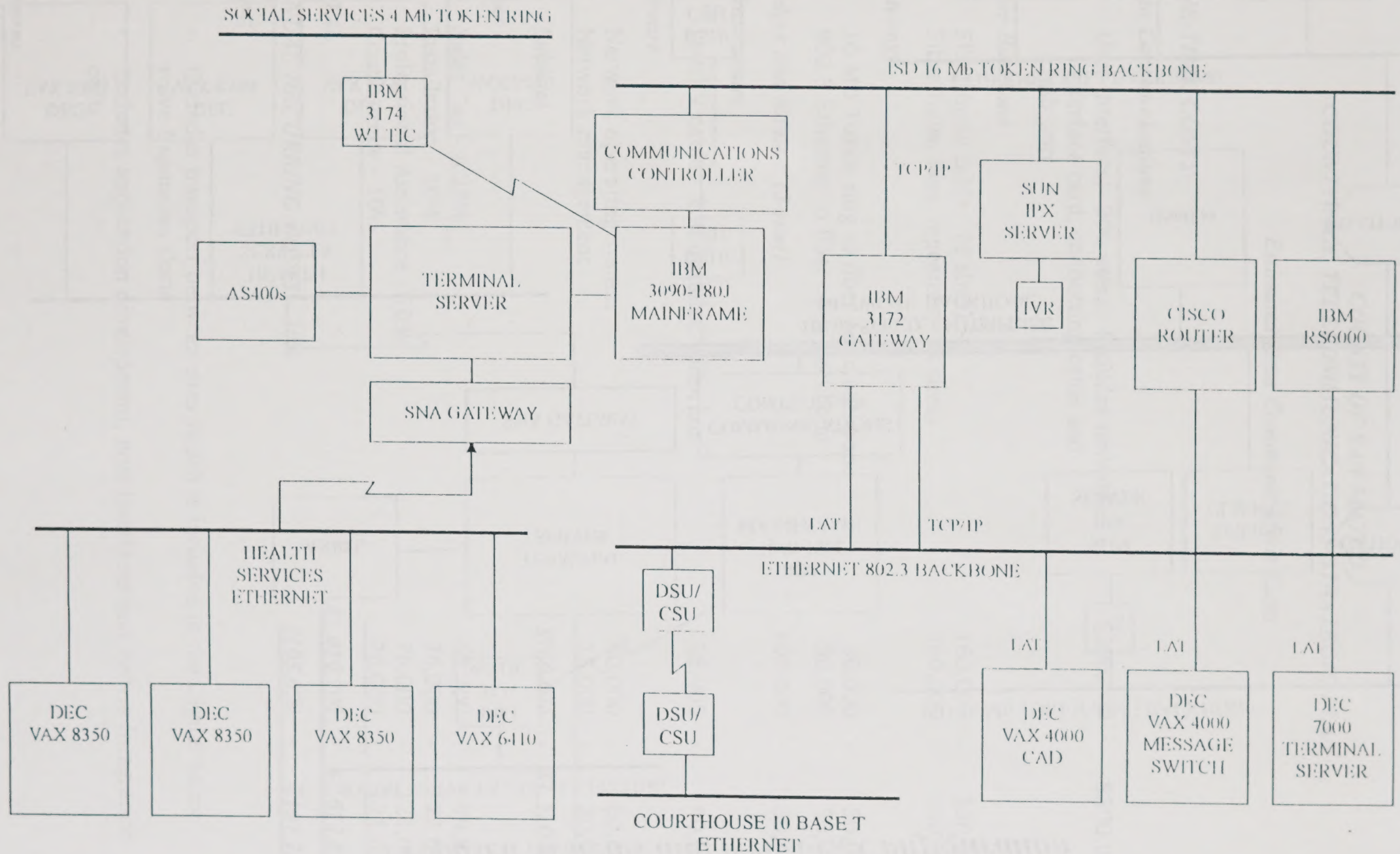
We believe that significant benefits should be derived by San Mateo County as a result of implementing our data system recommendations. Some of these are listed as follows:

- Client/server computing should utilize platforms and networks for their most efficient and effective purposes.
- Client/server strategies should provide the County maximum flexibility to incorporate evolving and future technologies.
- A redundant, protocol-independent enterprise network should support current and evolving technologies and provide the infrastructure necessary to enable the County to fully develop and implement advanced public access applications.

- Standards should ensure network and equipment compatibility and provide technical and procedural guidance to ISD staff and the user community.

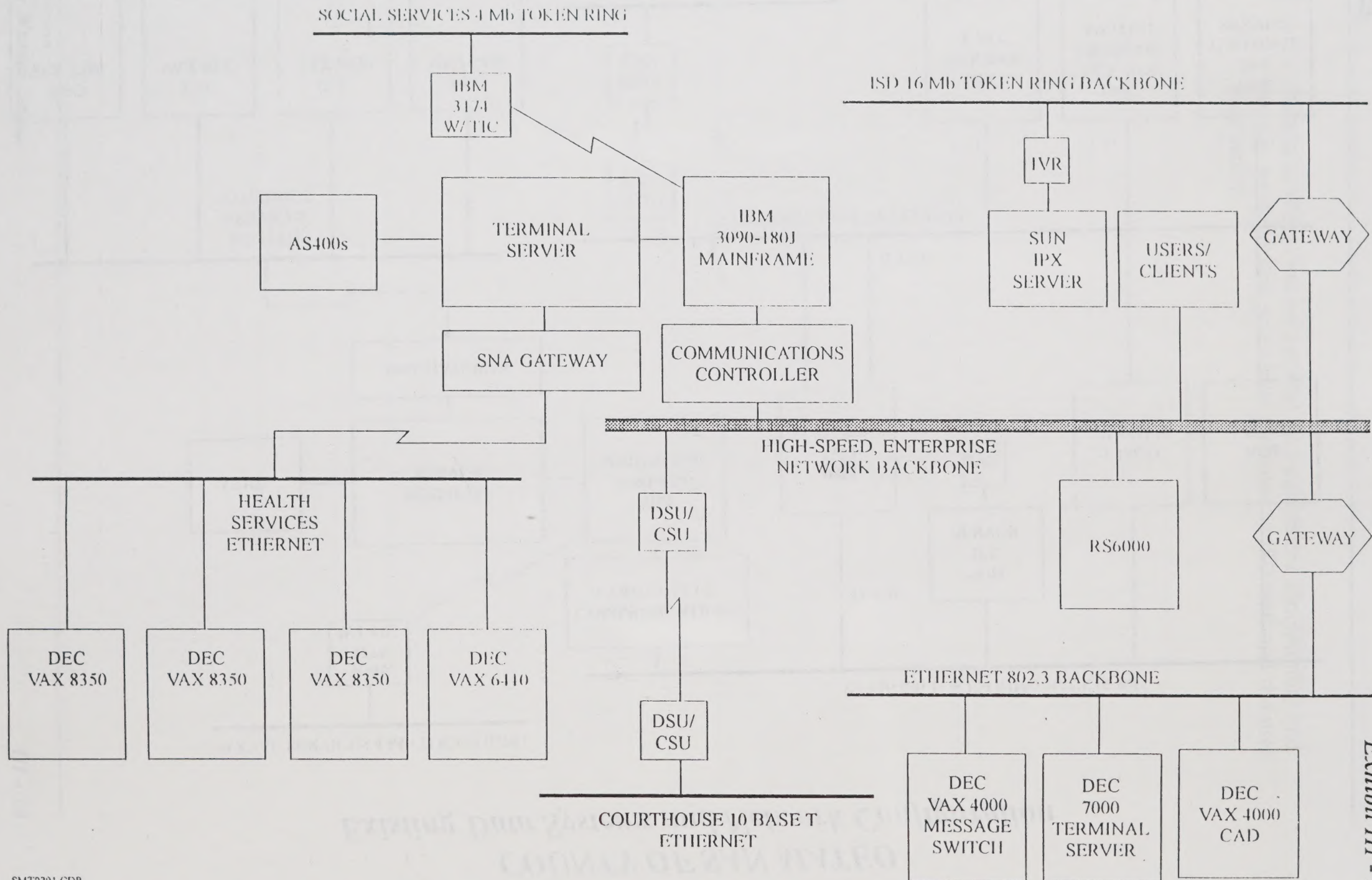
COUNTY OF SAN MATEO

Existing Data Systems and Network Configuration



COUNTY OF SAN MATEO

Proposed Systems and Network Configuration



COUNTY OF SAN MATEO
COUNTYWIDE TELECOMMUNICATIONS STRATEGIC PLAN

Estimated Data Communications Costs

ONE-TIME COSTS

Data Communications

User interface: 200 users. Includes network interface card, connecting cable and hub port	\$200,000	-	\$300,000
---	-----------	---	-----------

Fiber Backbone

Fiber optic cable: (8 sites)	160,000	-	320,000
Fiber hubs, taps, repeaters: (8 sites)	160,000	-	240,000

Gateways

16 Mb Token ring to fiber optic backbone	30,000	-	50,000
802.3 Ethernet to fiber optic backbone	30,000	-	50,000

<i>Bridges and Routers (8 sites)</i>	100,000	-	130,000
--------------------------------------	---------	---	---------

Infrastructure

Level V cable: 200 installed wire runs	25,000	-	40,000
--	--------	---	--------

Software

Network operating system	40,000	-	60,000
Network management	15,000	-	20,000

<i>Subtotal</i>	<u>\$760,000</u>	-	<u>\$1,210,000</u>
-----------------	------------------	---	--------------------

Other

Sales Tax - 8.25%	62,700	-	99,825
Installation - 10%	76,000	-	121,000
Professional Assistance - 10%	76,000	-	121,000
Contingency - 10%	76,000	-	121,000

TOTAL	<u><u>\$1,050,700</u></u>	-	<u><u>\$1,672,825</u></u>
--------------	---------------------------	---	---------------------------

ANNUAL RECURRING COSTS - 10%	<u><u>\$105,070</u></u>	-	<u><u>\$167,283</u></u>
-------------------------------------	-------------------------	---	-------------------------

Notes:

- Excludes transport between sites which is included in the Digital Microwave Expansion Costs
- Excludes application development, host interfaces and system integration costs

COUNTY OF SAN MATEO
DATA SYSTEMS
Implementation Plan

Exhibit III - D

	Year 1												Year 2				Year 3				Year 4				Year 5			
	1	2	3	4	5	6	7	8	9	10	11	12	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Data Communications																												
Develop & Document Detailed Network Design																												
Establish Standards																												
Develop RFP/RFQ																												
Issue RFP/RFQ to Vendors																												
(Vendors Respond)																												
Evaluate Proposal(s)																												
Finalize Budget																												
Select Network Vendor																												
Implement Backbone & Begin User Migration																												

SECTION IV

RADIO SYSTEMS

THE WARNER GROUP

IV - RADIO SYSTEMS

This section of our report contains our analysis of San Mateo County's radio communication system.

OVERVIEW OF CURRENT SYSTEMS

The Information Services Department supports seven radio systems which provide Countywide communications capabilities for public safety, EMS and public service agencies. The agencies supported by these systems include:

- Emergency Medical Services
- Fire Systems (County and City)
- Local Government (County)
- Parks and Recreation Department
- Public Works Department
- Sheriff's Department
- Law Mutual Aid

The County radio systems are supported by more than 50 radio site installations, including numerous voting receiver, control station and transmitter sites. Simulcast radio technology is utilized to provide wide area coverage throughout the county on eight strategically located hilltop sites. The simulcast radio backbone supports the following Departments and systems:

- Emergency Medical System
- Fire HAZMAT
- Information Services
- Office of Emergency Services
- Probation
- San Mateo County Law Mutual Aid (4 channels)
- Sheriff Primary Dispatch

The radio equipment ranges from three to twenty years in age. Most of the backbone simulcast site components were installed in 1975 and replacement parts are no longer available. Most of the radio system components have been supplied by Motorola, although several base stations were provided by General Electric. Exhibit

IV-A depicts an overview of the primary radio transceiver sites with their associated channels.

The County currently uses approximately 800 mobile and portable radios. User departments have periodically replaced out-of-date radios. The Sheriff's Department is the largest system user with approximately 300 mobile and portable radios in service. Many of the portable radios have been in operation for fewer than five years.

The following is a list of the radio channels currently in use:

Emergency Medical Services

Red Channel - Simulcast Tx 482.3125/Rx 485.3125 (Dispatch Channel)
Blue Channel - Simulcast Tx 482.7625/Rx 485.7625 (Ambulance to Hospital)

These channels are used for communications with the private ambulance services in the County.

Fire Systems (County and City)

Half Moon Bay Fire Department - Repeated Tx 154.3400/Rx 155.8950
Woodside Fire Department - Simplex TxRx 153.8900
State Fire White - Simplex TxRx 154.2800

Fire dispatch operations and mutual aid communications utilize these frequencies. The Woodside fire channel may be used for the South County Fire Districts when consolidation is complete.

Local Government (County)

Channel 1 - Simplex TxRx 45.4000
Channel 2 - Simulcast Tx 453.3250/Rx 458.3250
Channel 3 - Repeated Tx 453.5500/Rx 458.5500

These channels are designated for use by local government departments such as the Humane Society, Information Services, OES, Probation and Fire HAZMAT. Channel 1 is accessible from two transmitter sites. Channel 2 is simulcast from two locations. Channel 3 is transmitted from one location.

Parks and Recreation Department

Channel 4 - Simplex TxRx 151.4750

This channel is designated for use by the Parks and Recreation Department.

Public Works Department

Channel 5 - Repeated Tx 151.0100/Rx 159.0600

This channel is designated for use by the Public Works Department.

Sheriff's Department

Channel 6 - Simulcast Tx 488.9875/Rx 491.9875

Channel 1 is the primary dispatch channel for the Sheriff's Department. It is used for all dispatching and communications between Patrol, Investigations and the Communications Center. This channel is simulcast through six transmitters.

Channel 7 - Repeated Tx 488.3875/Rx 491.3875

Channel 2 is the primary dispatch channel used by the East Palo Alto, Brisbane and Half Moon Bay Police Departments.

Channel 8 - Simulcast Tx 488.8875/Rx 491.8875

Channel 3 is used by all law enforcement agencies in San Mateo County. It is called the Green channel and is used for interagency operations, pursuits and other emergency and non-emergency operations. Traffic is generally moderate. This channel is simulcast on four transmitters sites.

Tac 1 - Simulcast Tx 488.8625/Rx 491.8625

Tac 2 - Simulcast Tx 488.7125/Rx 491.7125

Tac 3 - Simulcast Tx 488.5375/Rx 491.5375

These are tactical channels used throughout the County for law enforcement operations. Tac 1 is used for northern County operations, Tac 2 is used throughout the central area of the County and Tac 3 is used in the south. Most radio traffic on these channels is emergency and non-emergency communications for mutual aid operations. These channels are simulcast through six transmitter sites.

Channel 7 - Simplex TxRx 488.9875

Channel 7 is used exclusively for the San Mateo Sheriff's Department for car-to-car communications throughout the County. Traffic is generally light.

Narcotics Task Force - Simplex TxRx 45.6600

This channel is used Countywide for narcotic surveillance operations.

Public Safety Communications Center

The County Public Safety Communications Center is located in the County Government Center and provides dispatch services for the following agencies:

- East Palo Alto Police Department
- Emergency Medical Services
- Half Moon Bay Fire Department
- Half Moon Bay Police Department
- Sheriff's Department
- Woodside Fire Department

The Communications Center houses eight radio and telephone console positions which are staffed at various levels twenty-four hours a day. The dispatch console designations include five Law Enforcement positions and three Fire/EMS positions. Operators at each console position handle both radio and telephone traffic depending on the level of dispatch center activity. The console equipment is based on Motorola Centracom Series I furniture and electronics that are over ten years old.

The County also utilizes a mobile radio communications vehicle to support off-site dispatching in the event of a major failure of the Communications Center or other specialized operations. In the past, this vehicle has been used as the primary dispatch point during fires and major earthquakes. This vehicle is equipped with two radio console positions, three telephone positions, cellular phones and other equipment to support short-term dispatching functions.

EVALUATION OF CURRENT SYSTEMS

A summary of the primary radio system findings include the following:

- *Simulcast Radio System Requires a High Level of Maintenance* - The simulcast radio system requires extensive maintenance to provide a high level of service and reliability to the public safety environment. Technicians must constantly adjust and align the system to maintain appropriate

coverage and audio quality. As a result, the radio communications unit must allocate considerable time to the ongoing maintenance of this system.

- *Radio Coverage is Adequate for Most Departments* - Coverage on County radio systems appears to be adequate in most areas. However, some marginal and non-coverage areas do exist within densely populated areas, as well as in more remote areas of the County. The lack of coverage in certain areas can be partially attributed to changes in building density since the time the system was installed, as well as to the changing requirements for access to more remote areas where population has increased.
- *Radio Traffic on Law Enforcement Channels is Increasing* - Radio traffic on many of the law enforcement channels is high, with peak activity periods decreasing the effectiveness of the system. Traffic on the EMS dispatch channel also has been increasing slightly. We understand that radio channel usage for most other County users remains light to moderate throughout the day.
- *Radio and Microwave Technicians Lack Test Equipment* - Test equipment for the radio and microwave systems is often unavailable. Technicians must frequently share equipment and schedule work repairs according to the availability of proper testing tools. The lack of appropriate equipment can delay the timeliness of repairs and is becoming a greater concern as critical system components fail more frequently.
- *Radio Backbone and Microwave Systems Well Documented* - The County radio and microwave systems are fully documented with both high level and detailed system diagrams. The availability of these design documents provides repair technicians with the fundamental resources required to troubleshoot system problems.
- *Existing Radio Backbone Provides Some Mutual Aid Communications* - The County's simulcast radio system supports four tactical mutual aid channels for use by all law enforcement agencies within the county. Fire agencies also have mutual aid channels available. The availability of these channels provides enhanced capabilities for emergency and non-emergency communications. However, there are limitations in mutual aid communications between law enforcement, fire, EMS and other local government users.
- *1994 Communications Budget is Limited to Current Maintenance Costs* - The County of San Mateo has only budgeted funds to maintain current equipment. If departments elect to purchase and implement new radio

equipment, those departments must also provide maintenance funds to ISD.

- *Backbone Upgrade Planned for Emergency Medical System* - The County plans to upgrade the radio backbone for the EMS radio system. We understand that funds for this project have been shifted from the ISD budget to a consortium of hospitals which will oversee the procurement and implementation. The County is not responsible for the implementation or maintenance of EMS mobile and portable radios.
- *User Equipment Inventory is Not Accurate* - In the past, the County maintained a listing of all mobile and portable radios. This list has not been updated and there is no accurate accounting system for mobile and portable radios.

NEEDS AND REQUIREMENTS

The Countywide radio network supports many system users with unique needs and requirements. The primary public safety and EMS backbone should provide uninterrupted communications throughout all County areas and support an interagency mutual aid network. Many local government users continue to rely on radio communications to enhance their departmental operation. Several County departments may investigate the use of mobile data communications to reduce voice radio traffic and provide access to key information systems.

	<u>Priority</u>
1. The Countywide radio system needs to provide coverage into all more highly populated and serviceable areas.	High
2. Public safety and EMS channels need to be supported by redundant components to minimize system downtime.	High
3. Radio coverage for public safety users needs to be at least 95% area coverage, 98% of the time.	High
4. Simulcast radio components must automatically monitor and adjust radio frequencies in overlap areas.	High

- | | | |
|-----|--|--------|
| 5. | The overall system design for public safety and EMS agencies needs to be capable of supporting in-building communications from portable radios. | High |
| 6. | New radio system and equipment should support the migration to new FCC regulations and resulting technology. | High |
| 7. | The backbone of the County radio system needs to support tactical and incident channels for mutual aid purposes. | High |
| 8. | Each law enforcement agency within the County needs to have access to Countywide mutual aid frequencies. | High |
| 9. | The radio system must support additional mutual aid radio channels to accommodate emergency and non emergency traffic between law enforcement, fire, EMS and other county users. | High |
| 10. | Emergency notification system needs to provide alarms back to the Public Safety Communications Center or ISD control station. | High |
| 11. | Some mobile radios require scan capability to permit monitoring of multiple radio channels. | High |
| 12. | Portable radios need to be capable of connecting to external microphones and headsets to maximize hands-free operation. | High |
| 13. | Radio coverage for EMS and non-public safety users needs to be at least 95% area coverage, 95% of the time. | Medium |
| 14. | The Countywide radio backbone should support unit radio transmission identification on all channels. | Medium |

	<i>Priority</i>
15. Mobile and portable user equipment for specialized law enforcement purposes needs to be capable of encrypted communications to enhance user safety.	Medium
16. The Countywide system should support a separate radio channel for mobile data and AVL communications. Coverage for this channel needs to be at least 95% area coverage, 98% of the time.	Medium
17. Radio coverage for all systems needs to be coordinated with anticipated growth patterns.	Medium
18. A separate radio channel needs to be included in the system design to ensure a communications link for radio maintenance personnel.	Medium
19. Field user radios need to be reprogrammable to support changing requirements and new features offered by the manufacturer.	Medium
20. Portable radio battery conditioners need to be provided to prolong field use.	Medium
21. Mobile radios need to provide horn alert for users who are frequently away from their vehicles.	Medium
22. Mobile data systems should be considered to enhance dispatch operations and reduce voice radio traffic.	Medium
23. Maintenance equipment used for testing needs to be approved by the system manufacturer for proper use and calibration.	Medium
24. The system needs to be capable of integrating standalone repeaters to support temporary operations in remote areas of the County.	Low

TECHNOLOGY OVERVIEW

Government radio technology itself is rapidly evolving and is being affected as well by forthcoming FCC rules and regulations. We have included an overview of the technologies and regulations that may affect the County's communications systems in the next five to ten years. These issues were considered in developing our strategic recommendations.

Simulcast Radio Systems

Simulcast radio systems are often used to support radio communications in areas where wide area coverage is required. A simulcast radio system transmits the same radio frequency through several radio sites which may be located in adjacent areas. Since the radio signal is transmitted at more than one location, additional radio equipment is required to synchronize the transmissions so that they are audible to a field user. Presently, the County utilizes a sophisticated simulcast system which covers eight radio sites in the north and south areas of the County. This particular system design helps to provide adequate coverage along the coast as well as the required coverage inland.

Due to the high reliability requirements of public safety, simulcast systems usually require to be connected via a microwave backbone. The microwave backbone provides reliability which exceeds that of leased telephone lines and also ensures that the path phasing is not affected by changes in central office locations or signal degradation. In addition, many microwave vendors now provide integrated simulcast components which work in conjunction with dynamic testing components.

Typically simulcast systems require higher maintenance due to the complexity of the timing equipment that must be utilized to ensure audio clarity. However, recent advancements in simulcast technology have resulted in dynamic testing and control equipment which monitors and corrects system phasing and frequency drift without technician intervention. As a result, it is often possible to service many simulcast

sites from one central location. These advancements in simulcast technology improve wide area coverage while minimizing maintenance costs.

Trunked Radio Systems

In response to the increasing demand for radio communications spectrum and resources in recent years, specific radio channels in the 800 MHz frequency range have been allocated by the FCC for public safety and local government use. New advances in radio and computer technology and regulatory changes mandated by the FCC have provided these new choices for communications systems.

To further increase radio spectrum efficiency and provide additional flexibility, a technique known as trunking was developed. The trunking technique used in modern radio systems is very similar to the type of trunking used in our public telephone systems. In both systems, individual communications pathways are shared among many different users.

Radio trunking has been mandated by the FCC for 800 MHz radio systems that use five or more channels. When properly designed and loaded with traffic, one channel within a trunking system can accommodate the needs of one hundred or more radio users. Computer control of the radio base stations and user equipment allows conversations to be transparently switched to available channels as traffic changes. This allows channels to be shared among many users groups rather than dedicated to a single group.

Trunked systems provide many advantages over conventional radio systems including greater protection from interference from other agencies and users due to much tighter control and allocation of spectrum resources by the FCC and APCO.

Trunked radio systems are designed to meet the needs of large cities, counties and states with many users from different departments. The systems also can be configured to meet the needs of multiple agencies within the same geographic region. Trunked radio systems are more costly than conventional systems. Typically, trunking can increase the cost of a radio system by 35 to 60 percent depending

on the configuration and sizing. The additional cost of trunking far exceeds the budgetary constraints of many agencies making the technology difficult to implement unless the costs are shared among several users. As a result, many agencies look towards shared and consolidated systems in order to implement trunking technology.

Specialized Mobile Radio System (SMRS)

SMRSs are privately owned radio systems whose owners lease air time to individual users. Implementing a Countywide SMRS system would present several advantages. The primary advantage is that SMRS backbones are already in place and would require no initial investment by the County. Since the backbone is in place, an SMRS system can be implemented very quickly. The SMRS also can serve as an interim solution while transitioning to a new radio system such as 800 MHz.

Although the apparent initial cost savings make SMRSs attractive, there are significant concerns regarding their appropriateness for public safety. SMRSs are for-profit enterprises and usage fees are negotiated on a case-by-case basis. Consequently, the usage fees that may be charged would likely result in higher long-term costs to the County. Also, SMRSs are not designed to meet the needs of specific users and it may be difficult to obtain the extensive, highly reliable portable radio coverage that is critical to a public safety communications system. Currently, the County uses an extensive simulcast backbone to provide complete Countywide coverage. To provide comparable performance, the County would need to find an SMRS system that provides simulcast coverage. Currently, there are no simulcast SMRS systems which cover San Mateo County.

There are also operational concerns which could negatively affect the use of an SMRS system. The SMRS vendor would be responsible for both the maintenance and management of the system and thus the County would have little control over its own operations. Performance standards and guarantees could be negotiated, but the County's communications would be dependent upon a single privately run

company. Given these significant issues, we feel that an SMRS solution would not be appropriate for the long-term critical communications needs of the County.

Digital Radio Systems

Digital radio technology is currently being developed for use in the VHF and UHF frequency spectrum for both conventional and trunking applications. Promising to be an improvement over current analog systems, digital radio systems translate an analog audio signal such as a human voice into a digital stream of ones and zeros. This stream of digital "bits" is then transmitted over the radio network and reconstructed at the receiving end. The receiving radio translates the digital stream back into an analog signal equivalent to the original voice message.

While the quality of analog communications can vary dramatically throughout a specific coverage area depending upon the received signal strength, digital communications should result in a much more uniform level of audio performance throughout a coverage area and should actually expand a radio's effective operational area. Additionally, digital communications should virtually eliminate the background noise associated with today's analog systems.

Currently, trunked radios from one vendor will not operate in a trunked mode on other vendors' trunked systems. To assist in preventing this problem with digital trunked radio systems, APCO, the FCC and the radio system manufacturers are developing standards to allow greater compatibility between disparate systems. These standards are being developed under a study commission by APCO, also known as Project 25.

The development of APCO Project 25 standards has been underway for several years and was scheduled to be completed earlier this year. The two largest vendors of trunked radio systems, Ericsson GE and Motorola, have differing views on what form the standard should take and it appears that the standard will probably not be adopted within the next six months. Indeed, it may be several more years until APCO Project 25 standards are solidified and supported by the manufacturers. It is

expected that digital systems will initially cost twenty to thirty percent more than corresponding analog systems.

FCC Regulation

To deal with the increasing popularity of land mobile radio and the resulting demand for radio spectrum, the FCC is proposing a replacement of Part 90 of the FCC rules and regulations with a new Part 88 that will govern all radio operations below 512 MHz. The primary purpose of this change is to provide more capacity in the radio spectrum in order to accommodate existing and future users. Although the new Part 88 has not yet been adopted, The FCC has published a "*Notice of Proposed Rule Making*" which details the changes which are planned. The following analysis of the impact of those changes on the County is based on Part 88 as it is currently planned, and may need to be revised if the substance of Part 88 changes.

There are two significant changes in the proposed Part 88 which have potential to tremendously impact communications within the County. These two areas, the splitting of existing channels (also known as "refarming") and the reduction in transmission power as a function of tower height, are described below:

Refarming - The refarming mandated by Part 88 involves two specific activities: 1) reducing the space required by radio channels in order to create open or "green" space between the channels and 2) creating additional channels between the existing channels. The FCC has proposed that this migration take place in two steps: a reduction from the current bandwidth of 25 KHz initially to 12.5 KHz and then finally to 6.25 KHz for some frequencies and 5 KHz for others. The first change would be required by 1996, and there are concerns about whether existing equipment could be effectively tuned to operate within 12.5 KHz. Given the age and condition of the County's radio backbone, it may be impossible for some existing equipment to meet the specifications proposed for 1996.

The second change, from 12.5 KHz to 6.25 KHz/5 KHz, would be required for all new equipment installed after 2003; additionally, existing equipment would have to

be replaced with equipment that meets the new standard by 2012. It is important to note that the very narrowband equipment necessary for the jump to 6.25 KHz/ 5 KHz channels has not been developed and there is no assurance that it will exist in the future. Several significant technological problems must be solved before appropriate equipment can be produced. Consequently, APCO has recommended to the FCC that the final narrowband specifications be reviewed several years after the interim move to 12.5 KHz bandwidths has been completed.

Although the final specifications for refarming will certainly change over time, it is clear that, even under the most flexible standards currently proposed, San Mateo County will likely have to replace the majority of its radio equipment in upcoming years.

Power and Height Requirements - In addition to the refarming that is proposed by Part 88, there is plan to limit the effective radiated power (ERP) emitted by an antenna based on the antenna's height above average terrain (HAAT). The purpose of this limitation is to decrease the coverage of individual sites and permit frequencies to be reused on a more frequent basis. Although this requirement has received far less attention than refarming, it has the potential to impact operations just as dramatically. The current proposal limits ERP by antenna height.

The proposed requirements would drastically reduce the signal levels from the existing hill tops and towers, and result in significantly less radio coverage. As a result, additional towers would have to be constructed in order to restore coverage to existing levels. Many of the radio transmitter sites in San Mateo County would be affected by this proposal.

ALTERNATIVES ANALYSIS

As part of our analysis, we examined several alternatives for meeting the current and future radio communications needs of San Mateo County focusing on growth, reliability, interoperability and coverage as well as impending technology and FCC regulations. The radio network alternatives fall into two general categories:

-
- Develop a Regional 800 MHz Trunked Radio Communications System
 - Upgrade and Enhance the Existing VHF/UHF Systems

In addition, we have provided an analysis of the various mobile data communications systems that could be used to enhance field communications.

Develop an 800 MHz Trunked Radio System

One of the primary options for the County would be to replace the existing VHF/UHF radio system with newer technology in the 800 MHz radio spectrum. Since 1983, radio channels in the 800 MHz spectrum have been allocated for public safety and local government use in states, counties, cities and special districts by the FCC. These channels have become available due to the increasing demand for radio communications spectrum and resources. The most recent allocation included 120 additional channels that were released under the control of the APCO, Northern California Regional Plan that was adopted by the FCC in November, 1990. Six 800 MHz channels have been set aside for San Mateo County as part of the reallocation of the Northern California APCO plan.

Although trunked radio systems offer numerous benefits, such as those outlined in the technology overview section, a significant disadvantage is high initial cost due to the required replacement of all existing radio equipment. The migration to a new 800 MHz trunked radio system would be more complex to implement and would be more disruptive to current operations than upgrading the existing VHF/UHF system. In addition, the six available channels would not be adequate to meet the current or future needs of the County and it may be difficult to impossible to acquire additional channels at this time. Although the northern California frequency allocation plan has recently been reopened, it still does not appear that additional channels will become available. The six channels that are allocated have a realistic maximum capacity of meeting 400 to 500 of the County users. Based on the current use of approximately 800 radios and a growth expectation of 1200 radios, it would not be possible to meet the full needs of the County. If only a portion of the users moved

to 800 MHz, it would hinder interdepartmental and mutual-aid communications throughout the County.

The estimated one-time cost to implement an 800 MHz trunking system for San Mateo County including a seven-site, simulcast backbone and the replacement of all user equipment would range from \$8,000,000 to \$10,000,000. Of this cost, an estimated \$1,700,000 to \$2,500,000 would be for new user equipment based on 800 radios. The total project cost could increase if it were determined through further analysis that the backbone required additional sites to improve coverage. The inclusion of other users within the County also would increase the cost of the system.

Upgrade and Enhance the Existing VHF/UHF System

The existing VHF/UHF radio system has performed adequately for law enforcement, fire, EMS and local government services since the system was implemented in 1975. To further improve the reliability and performance of the system, the selected components, such as the primary base stations and repeaters, which include units that are nearly 20 years old, could be replaced. Specific voting receiver equipment could be upgraded and additional sites added to the network to fill in some poor coverage areas. Additional channels and patching systems could be added to the system to enhance mutual aid and interagency communications. Current capacity problems could be reduced by implementing a mobile data communications system. Such a system would alleviate traffic on law enforcement channels. Also, the communications center could be upgraded with newer consoles and related equipment. We estimate that approximately 500 new user radios would need to be purchased to replace existing outdated equipment and to provide for growth.

The primary advantage of the upgrade and enhance the existing system approach is that it would be the least costly alternative for upgrading the radio network to enhance reliability and increase capabilities. The upgrades could be phased allowing for the costs to spread over a longer period and minimizing disruption to the overall County operations. Another advantage is that some of the existing equipment could

be reused to enhance coverage in certain areas of the County. Due to the nature of radio frequency transmission characteristics, VHF/UHF channels provide better coverage over a wider area than 800 MHz. The use of simulcast technology assists in providing improved in-building coverage in dense areas. As a result, the County would continue to benefit from wide-area usage of primary and mutual aid frequencies.

As noted previously, APCO and the FCC are in the process of studying the potential for "refarming" the radio spectrum below 512 MHz. The results of this process will likely make digital and trunking technology as well as other new state-of-the-art capabilities available within the VHF/UHF frequency spectrum in the next four to eight years. As a result, equipment capable of operating within FCC guidelines should soon become available. This, coupled with mobile data technology and the expected low growth levels in San Mateo County make a phased upgrade a viable alternative.

The estimated one-time cost to upgrade and enhance the existing VHF/UHF radio system including new network components and the replacement of the older user equipment would range from \$3,329,000 to \$4,378,000.

Mobile Data

Mobile data technology is rapidly being adopted to enhance field communications for public safety, EMS and local government users. Some of the technologies currently available include Mobile Status Terminals (MSTs), Mobile Data Terminals (MDTs), laptops, Mobile Data Computers (MDCs) and Automatic Vehicle Location (AVL) systems. This section of our report contains our analysis of the alternative mobile data systems that could be utilized to enhance operations.

One of the key applications for mobile data technology is the automatic update of unit status to a Computer Aided Dispatch (CAD) system. Transmitting status changes over a data radio channel reduces the amount of traffic on the voice radio system and can provide more accurate information for incident reporting. Mobile data devices can also provide detailed dispatch information, such as directions to the

incident and premise history, directly from the CAD system to field units. Another use of mobile data is automated field access to critical databases such as wants and warrants, CLETS, NCIC, and hazardous materials. In addition, mobile data systems and applications are being developed to provide report writing and processing capabilities in the field. AVL technology provides the ability to track the exact location of field units and identify the most appropriate unit available for each incident. A detailed description of mobile data technologies follows.

Mobile Status Terminals (MSTs) - The entry level of mobile data technology utilizes MSTs, which are multi-button key pads that electronically communicate changes in unit status to the computer-aided dispatch (CAD) computer. The CAD system captures and records status changes without requiring dispatcher intervention. Due to the short length of the data message, these units are sometimes implemented on existing voice radio channels. This, however, can result in digital "noise" being picked up by voice radio. Consequently, it is preferable to implement mobile status on a separate radio channel. MSTs provide for the recording of all field unit status information on a real-time basis, which enhances time reporting and allows dispatchers to quickly identify all units available to respond to an incident.

The estimated one-time costs for a mobile status terminal system with 200 units would range from \$625,000 to \$875,000.

Mobile Data Terminals (MDTs) - The next level of mobile data technology utilizes MDTs. MDTs are computer terminals that are mounted in a vehicle and have a screen and keyboard, along with status keys similar to an MST. The MDT is a two-way communications device offering significantly more capabilities than the MST. MDTs allow users to request information from various databases and receive messages from several sources. An MDT poses some limitations in comparison to an office terminal or personal computer. MDTs have smaller keyboards and screens to compensate for space restrictions within vehicles. In addition, the size and placement of the keyboards usually limits the ability to enter extensive narrative reports.

Due to the unique screen size, each screen or inquiry capability of the MDT must be pre-programmed. There also is some programming effort required to prepare the host computer for communicating with the same protocol and characters utilized by the MST, but this pre-programming offers certain advantages. Critical messages may be defined in advance and transmitted automatically when a law enforcement, fire or EMS vehicle responds to an incident. Also, call detail information, hazardous materials, directions to the incident or historical information may be provided to enhance the safety of field personnel.

~~The estimated one-time costs for an MDT system for 200 County units should range between \$1,250,000 and \$1,625,000.~~

Mobile Data Computers (MDCs)/Laptops - The latest approach to mobile data technology involves the use of specialized vehicle or laptop computers. These computers are used to emulate MDTs for traditional mobile data functions, such as status updating and CAD system messaging, but they also allow DOS based applications such as word processors and spreadsheets to be accessed in the field. The larger screen and keyboard overcome some of the disadvantages of the standard MDT that were mentioned above.

Concerns have been raised, however, about the reliability of standard PCs in such demanding environments as police, EMS and fire vehicles. Responding to these concerns, vendors are enhancing their MDTs to provide both MDT and PC functionality in a ruggedized, highly reliable package known as an MDC. Their enhanced reliability make MDCs the device of choice when both MDT and DOS functionality are needed.

Based on preliminary cost estimates from vendors, one-time costs for an MDC system with 200 units should be between \$1,369,000 and \$2,425,000.

Automatic Vehicle Location (AVL) - Automatic Vehicle Location systems communicate a vehicle's location to a dispatch computer. Although these systems have been available for many years, this mobile data technology has only recently emerged for use in conjunction with other mobile data technologies such as MDTs and MDCs.

Several different technologies can be utilized to track vehicle location. In one method, a radio receiver and computer in the vehicle receive the same LORAN radio signals that ships at sea use for position determination. Another method uses a compass and odometer in the vehicle to keep track of the vehicle through "dead reckoning." One of the newest AVL technologies is the Global Positioning System (GPS) that utilizes signals from satellites to track individual units. In each case, the location is periodically transmitted back to a communications center computer which can display the vehicle's position on an electronic map.

One of the primary applications for AVL includes using vehicle position information and the CAD computer to enable dispatchers to assign the most appropriate unit(s) for each incident. AVL systems also are used to enhance the safety of field personnel. In critical situations, when voice radio transmissions are not possible, dispatchers can easily determine the location of a vehicle from the AVL display.

AVL systems may be implemented as standalone systems, but require much of the same hardware as an MST, MDT or MDC system. A more practical approach is to implement one of the mobile data systems and then use the existing data backbone to support AVL. Under this approach, one-time costs for a 100-unit AVL system should range between \$546,000 and \$625,000.

RECOMMENDATIONS

Our recommendations for improving the County's radio systems are as follows:

Backbone

1. *Upgrade and Improve the VHF/UHF Radio Backbone* - Although the existing VHF/UHF radio system has provided adequate service over the past 20 years, some of the system components have exceeded their expected life cycle. The backbone includes 28 simulcast repeaters which should be replaced immediately in order to provide continued reliable service and reduce ongoing maintenance expenses. The replacement of equipment would impact the Sheriff, County Local Government, EMS and law enforcement mutual aid systems and could be phased over the next few years based on criticality and as existing components fail. The public safety equipment is the highest priority. Replacement components should

be designed to operate within new refarming specifications and take advantage of new digital technologies.

Operationally, a county-wide 800 MHz trunked radio system shared with other regional users and, possibly, surrounding counties would be the best overall solution. However, as noted in our analysis, the primary hurdles that must be overcome include a lack of available frequencies, high cost and the long lead time necessary to forge formal agreements. As an alternative to immediately pursuing the VHF/UHF upgrades, the County may wish to explore the region's interest and support in a shared 800 MHz system.

2. *Plan for Changes in FCC Rules of Operation* - The County of San Mateo should actively plan for radio system upgrades due to impending FCC rule changes. We recommend that a countywide steering committee be developed to monitor rule changes and oversee planning efforts. The committee should begin planning for a significant upgrade of the regional radio systems as a result of the regulations. This upgrade will likely be required in the next five to six years. Part of the plan should consider the development of a cooperative funding and financing plan for all of the participating regional users.

In addition, the committee should actively pursue the development of improved mutual aid communications by sharing access to channels as well as acquiring new channels for countywide, multi-discipline use. For example, law enforcement, EMS and local government users should have a common UHF channel for mutual aid operations. Communications with fire users on VHF channels could be accomplished through improved dispatch coordination and patching capabilities.

3. *Consider Implementation of Additional Sites* - As part of the simulcast system upgrade, the County should evaluate the feasibility of implementing additional transmitters and voting receivers to enhance communications capabilities. As part of the backbone upgrade, detailed propagation maps should be developed and reviewed to determine coverage patterns in all County areas. Key personnel from each user department should be consulted to determine requirements for radio coverage.
4. *Replace Outdated Mobile and Portable Radios* - Currently, the County uses approximately 800 mobile and portable radios. Some of the radios that are in use are over 15 years old and require excessive maintenance. To ensure reliable communications, these radios should be replaced in a phased manner during the next few years. We have included costs for 500 new mobile and portable radios to meet replacement as well as growth needs.

5. *Implement Dynamic Testing Components* - An automatic simulcast phasing and frequency monitor system should be installed to enable single point maintenance. This system should enable maintenance personnel to adjust all aspects of the simulcast system from one central location. These components should also automatically adjust for minor variance in phasing and frequency drift without technician intervention.

Mobile Data

1. *Implement an MDC/Laptop System for the Sheriff's Department* - An MDC/laptop mobile data system should be implemented for the San Mateo Sheriff's Department to provide CAD information and direct access to NCIC, CLETS, CAD and RMS. The MDC system should provide access to DOS applications for improved field reporting capabilities. The system should be designed to accommodate the needs of EMS users in addition to the Sheriff. We recommend that this system be implemented on a standalone radio channel to minimize impact on current radio systems and enable greater throughput.
2. *Consider AVL for Sheriff and EMS Applications* - The County should consider the implementation of an AVL system for public safety and EMS field units. Phasing AVL at a later time should enable the County to augment the mobile data network and combine technology innovation.

ESTIMATED COSTS

The estimated one-time costs to upgrade the Countywide simulcast radio system should range from \$3,328,868 to \$4,377,773. These costs are detailed in Exhibit IV-B. We have included costs for repeaters, control station equipment, building renovations and user equipment. The estimated one-time costs to implement a 200-unit mobile data computer system should range from \$1,369,235 to \$2,425,360. The mobile data costs are detailed in Exhibit IV-C.

The estimated annual recurring costs to support the recommended upgrade to the Countywide simulcast radio system should range from \$332,887 to \$437,777. The estimated costs to maintain the mobile data system should range from \$136,924 to \$242,536. These costs are estimated based on full service vendor maintenance contracts. The costs could be less if the County were to continue providing in-house maintenance services.

IMPLEMENTATION PLAN

The County should immediately begin developing specifications for improving the simulcast radio system to meet the needs of the public safety, EMS and local government users. New mobile data radio backbone and user equipment should also be included in this procurement process to ensure vendor commonality and control through the project life cycle. The implementation of the new voice radio equipment should be implemented within the next eighteen months while the mobile data system should be implemented in Year 3. In addition, the County should form a Countywide radio steering committee to begin planning for operational improvements and changes in the FCC rules.

BENEFITS

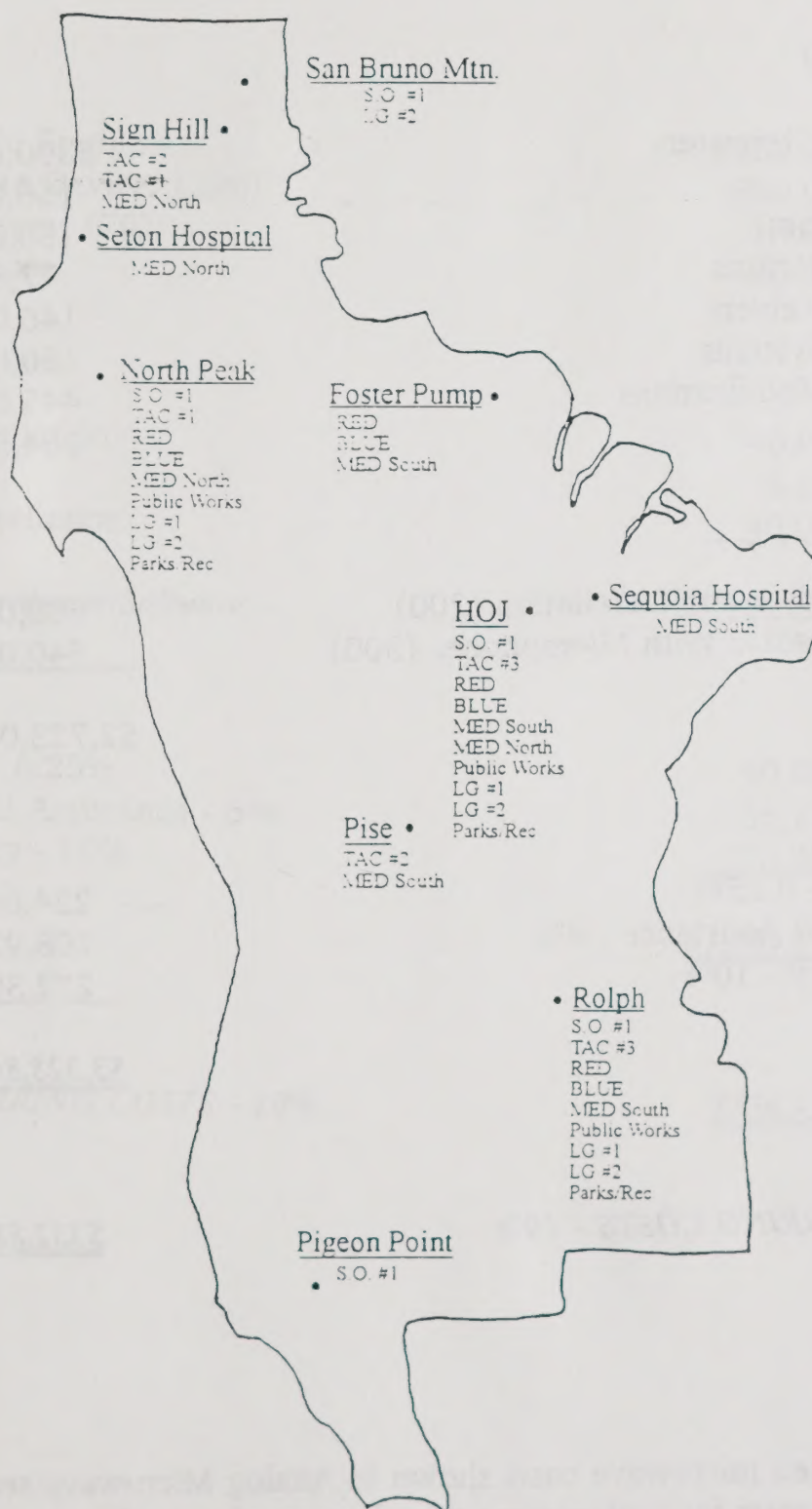
We believe significant benefits should be derived by San Mateo County as a result of implementing our radio system recommendations. Some of these are listed as follows:

- New equipment should improve performance, coverage and quality of the simulcast radio transmissions throughout the County.
- Provides the ability to implement necessary changes and plan for new technology as a result of refarming.
- Allows for phasing of equipment acquisitions so that future technology decisions may incorporate emerging systems developments and FCC plans.
- Reduces maintenance time through utilization of dynamic test equipment designed to optimize simulcast radio transmissions.
- Utilizing VHF/UHF frequencies maintains countywide mutual aid capabilities with all agencies.
- A mobile data system will reduce voice radio traffic on primary channels providing more air time for essential voice communications.
- Enhanced access to internal information systems as well as CLETS and NCIC should increase field user effectiveness and reduce dispatcher workloads.

- Utilizing mobile data in conjunction with CAD will enable standardized responses for cleared incidents and enable field units to clear calls without assistance from the Public Safety Communication Center.
- Integrated AVL could improve emergency services responses to critical incidents throughout the County as well as assist with emergency management operations.

COUNTY OF SAN MATEO

Countywide Radio Tranceiver Sites



COUNTY OF SAN MATEO
COUNTYWIDE TELECOMMUNICATIONS STRATEGIC PLAN

Estimated Simulcast System Upgrade Costs

ONE-TIME COSTS

Fixed Equipment

Simulcast Repeaters	\$390,000	-	\$468,000
UPS	156,000	-	192,000
Comparators	150,000	-	180,000
Control Stations	77,500	-	93,000
Voting Receivers	140,000	-	196,000
Antenna Systems	160,000	-	247,000
Building Modifications	445,000	-	530,000
Installation	164,500	-	195,000

User Equipment

Mobile Radios and Installation (200)	500,000	-	640,000
Portable Radios With Microphones (300)	540,000	-	840,000

Subtotal \$2,723,000 - \$3,581,000

OTHER

Sales Tax - 8.25%	224,648	-	295,433
Professional Assistance - 4%	108,920	-	143,240
Contingency - 10%	272,300	-	358,100

TOTAL \$3,328,868 - \$4,377,773

ANNUAL RECURRING COSTS - 10% \$332,887 - \$437,777

Notes:

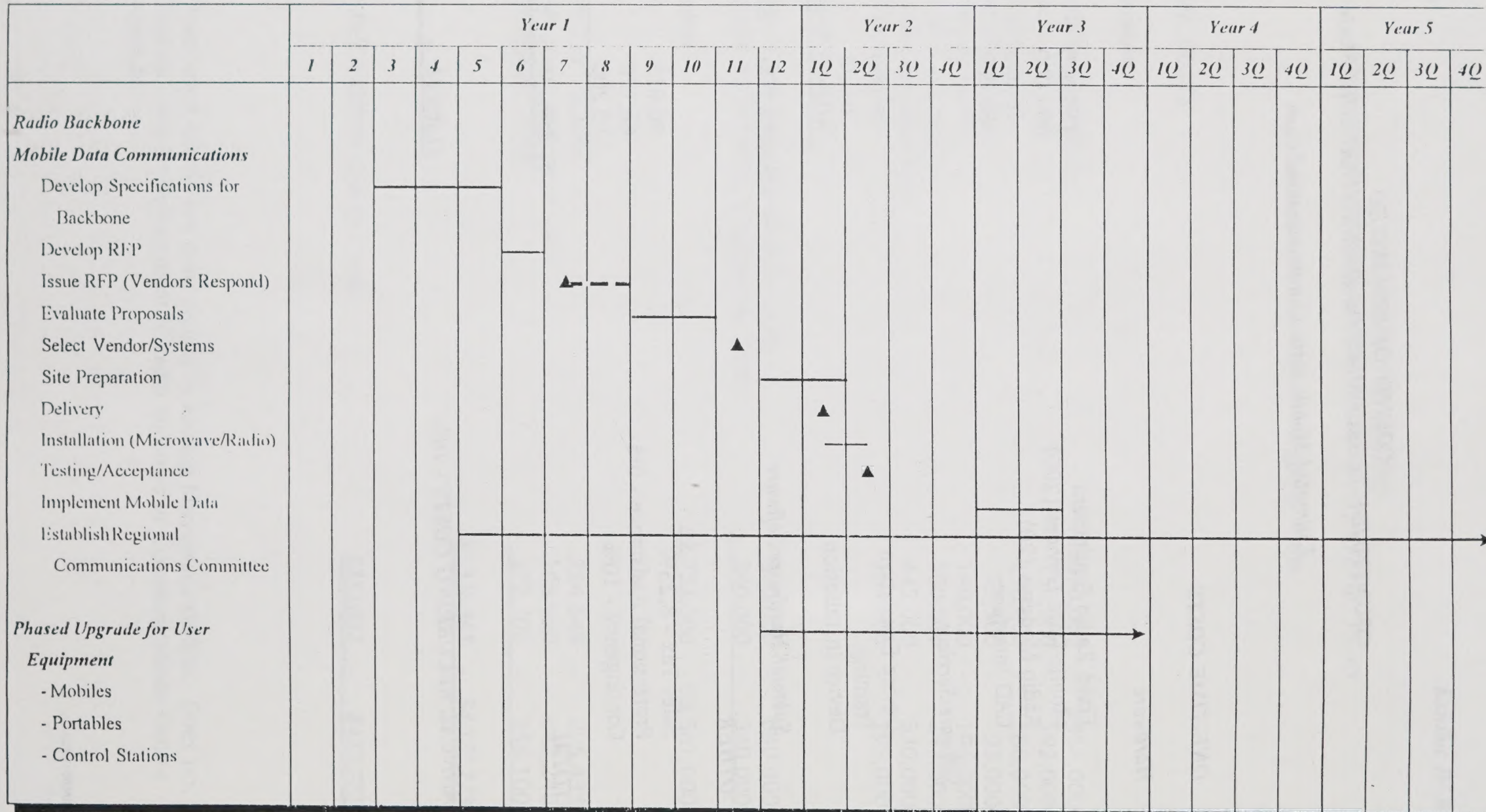
- Associated microwave costs shown in Analog Microwave section. Does not include costs for replacement of radio consoles or Communications Center upgrades.

COUNTY OF SAN MATEO

RADIO SYSTEMS

Implementation Plan

Exhibit IV - 1



SECTION V

INFRASTRUCTURE

THE WARNER GROUP

This section of our report contains our analysis of the County's common infrastructure components that support the various communications systems throughout the County.

OVERVIEW OF CURRENT SYSTEMS

The County utilizes a common communications infrastructure to meet the transport and connectivity requirements of the voice, data and radio communications systems. The two primary components of the system are microwave and wire and cable.

Microwave

The County of San Mateo uses both digital and analog microwave radio networks to support voice and data and radio communications throughout the County. Together, these microwave networks include nearly 34 communications paths which are maintained by the Information Services Radio/Microwave unit. The following is a description of the major components of the analog and digital microwave systems and a summary of our key findings.

Analog Microwave - The analog microwave network comprises 25 links and is the primary supporting infrastructure for the County's simulcast radio system. This microwave network provides communication paths to each of the primary radio transmitter sites as well as numerous voting receiver sites located throughout the County. The analog microwave system also supports an Office of Emergency Services telephone system which provides three-digit voice communications between all public safety, hospital and emergency services offices in the County, and limited data communications for County and local city agencies. An overview of the current analog network is shown in Exhibit V-A.

Additional applications supported on the network include the San Mateo Regional Telecommunications System (SMARTS) which enables law enforcement agencies to access state and national databases through the County message switch. The analog microwave network also supports voice and data applications for the San Mateo Transit District (SAMTRANS).

Inter-county mutual aid communications are provided through the analog microwave system. The analog network is part of the Bay Area Communications Information System (BACIS), which enables voice and data connectivity through an inter-county system.

The analog microwave system was initially installed in 1975 to support the County-wide law enforcement radio network. It now also supports the Fire, EMS and local government radio networks. One link operates in the 960 MHz range, eight operate in 2 GHz band, eight operate in the 6 GHz band, and eight in the 23 GHz band. Since the analog microwave network was built to support multiple communication functions, many of the links can support up to 600 channels. None of the links in the analog microwave system have redundant paths or routing.

Digital Microwave - San Mateo County's digital microwave network comprises nine paths, each of which functions as an individual system. Eight paths are configured for hot-standby operation for redundancy. This system is used to interconnect the County's eight Northern telecom telephone communications systems and several remote sites in the East Palo Alto area. Some data transmission, primarily for Hillcrest and the Northern Courts, is also supported by the digital microwave system.

The digital microwave was installed in 1988, concurrent with the implementation of several Northern Telecom SL-1 voice communications systems. All paths are currently equipped to support four T-1 circuits, or 6 Mb, but the maximum path bit rate varies. Two paths support up to 45 Mb, three support up to 26 Mb and the remaining four support only the 6 Mb for which they are equipped.

Similar to the maximum path bit rate, the operational frequency band varies among paths. Three paths operate in the 6 GHz band and six in the 18 GHz band. Except for the path to East Palo Alto, all hops on the digital microwave system are redundant, and in the event of a failure, switchover occurs automatically. Exhibit V-B depicts the configuration of the digital microwave system.

Wire and Cable

The County also utilizes an extensive wire and cable infrastructure to support the communications requirements within buildings as well as between campus buildings. The cable plant between campus locations consists of County-owned landlines and leased cable facilities, as well as some abandoned telephone company cable facilities. The current cable plant is copper, but some consideration has been given to installing fiber between the County Operations Building and the old Courthouse to support data applications. Dual wire and cable systems for telephone and data are maintained throughout the Redwood City complex.

Specifications for the station cable within buildings supporting individual user's voice and data connectivity requirements vary. Over the past year, new wire runs have been level III, with six pairs per run. Previously installed station cable may consist of three or four pairs of standard twisted pair wire, as well as some coaxial cable installed for data connectivity. Recently, Level V cable has been installed to support Human Services and Information Services requirements.

EVALUATION OF CURRENT SYSTEMS

The following is a summary of major findings associated with the County's existing infrastructure:

Microwave

- *Analog Microwave Network is Not Redundant* - The analog microwave system is not configured with redundancy to ensure reliable operations. In the event the County experiences an equipment or path failure, services for the public safety and EMS radio systems, SMARTS and other related systems could be severely impacted.

- *Digital Microwave System is Mostly Redundant* - Unlike the older analog system, all but one path on the digital microwave system are redundant and operate as hot-standby units with automatic switchover. The East Palo Alto path is not redundant, resulting in a potential point of failure since all voice communications services to this area are directly controlled through the SL-1 in Redwood City.
- *Critical Analog Microwave Components are Outdated* - Some critical components of the analog microwave network are aging and have exceeded their normal life expectancy. Although the older components have been reliable, service personnel believe that the age of the equipment may be a contributing factor to the high maintenance requirement of the simulcast radio system.
- *Analog Microwave Capacity is Limited By Equipment Room Space* - The analog microwave system is capable of supporting up to 600 channels on the primary network links. However, some nodes cannot be expanded to maximum capacity due to the lack of available equipment room space. Should new channels be required for future operations, significant equipment room modifications could be required.
- *Some Digital Paths Are Equipped to Capacity* - At least two digital microwave paths are currently equipped to their 6 Mb capacity. Due to the lack of expansion potential, the ability to provide additional T-1 circuits to accommodate heightened user need in several areas such as data and video communications is limited.
- *Limited Microwave Support Resources Available* - The Communications unit of the Information Services Department employs one technician whose responsibilities include microwave system support. Due to analog system age and frequency of repair, microwave system maintenance currently requires a full-time support resource. No backup to this resource has been identified.
- *2 GHz Microwave Links May Need to be Updated* - The Federal Communications Commission is currently evaluating the reallocation of the 2 GHz spectrum. Should this refarming occur, the County may be required to upgrade its existing 2 GHz links to another band, which would necessitate the purchase of new microwave components.
- *OES Telephone System Lacks Support* - The Honeywell Delta-Plex switch used to provide three-digit microwave system dialing capabilities is no longer supported. This switch has required no troubleshooting since 1985. However, documentation for move, add and change procedures is not available.

Wire and Cable

- *Cable Plant Documented for Key County Sites* - The Communications Current Environment document includes basic illustrations of the campus cabling plans and riser cable pair distribution by floor. These diagrams note the number of cable pairs installed between buildings and floors and the facility source (County-owned or leased). For key locations, details of riser cable distribution among wiring closets also is provided. Documentation of station cable assignments is not included.
- *Integrity of Abandoned Telephone Company Cable Unknown* - The County "inherited" some cable plant when these facilities were abandoned by the local telephone company. The long-term integrity of this cable is suspect, thus limiting the viability of including these facilities in future cable plans. Also, the cable typically is of a lower grade which is not suitable for high speed data communications.
- *Standards For Station Wire Emerging* - ISD has recently established Level V as the standard for all new station wiring. This standard is key to providing maximum flexibility for future high speed communications connectivity.
- *Cabling Retrofits could be Problematic* - Current facility remodeling plans include installation of new cable to meet present standards. However, in some facilities, such as the old Courthouse, structural or environmental conditions could complicate or prevent re-cabling efforts.

NEEDS AND REQUIREMENTS

Microwave

The analog and digital microwave systems support radio, voice and data communications. The microwave network is a primary component of the public safety and EMS radio backbone and requires redundant components and alternate path routing. Future voice and data needs continue to increase; thus, the supporting microwave system must accommodate large channel capacities at each primary site.

	<u>Priority</u>
1. The microwave systems should be designed to support the transport of radio, voice and data systems throughout the County.	High

- | | | |
|-----|---|------|
| 2. | The microwave systems need to support bandwidth required for the development of video-conferencing and imaging applications for justice, training, law enforcement, Human Services and Health Services functions. | High |
| 3. | The microwave systems need to support the capacity requirements of a high-speed data communications infrastructure. | High |
| 4. | The microwave network needs to be configured and engineered to support the continuous operation of voice and data systems. A minimum of 99.95% end-to-end reliability is required for each system link. | High |
| 5. | Microwave radios and critical multiplex equipment need to be supported by redundant components for high-reliability. | High |
| 6. | Each microwave equipment room needs to be configured to support additional channel banks and equipment racks to meet future system needs. | High |
| 7. | The microwave network needs to interconnect to an automatic synchronization system used to maintain simulcast radio communications. | High |
| 8. | Radio frequencies used within the microwave network need to be carefully planned in order to avoid future frequency conflicts with new technologies and frequency redistribution. | High |
| 9. | The redundant or hot-standby equipment in operation for each link needs to automatically sense equipment failure and switch between active and standby components. | High |
| 10. | The systems need to support "drop and insert" channel capability throughout the network for telephone, voice and data communications. | High |

	<i>Priority</i>
11. An alarm system needs to be provided. Alarms should at least be displayed for transmitter failure, receiver failure, power failure, and hot-standby switchover or alternate route.	High
12. All microwave equipment shall be accepted and approved for operation under Part 94 of the FCC rules and regulations.	High
13. Antennas need to be compliant with FCC category "A."	High
14. Multiplex equipment shall be specifically designed for simulcast systems.	High
15. Backup batteries and chargers at each RF terminal location shall be capable of powering microwave and multiplex equipment for a minimum of eight hours.	High
16. All components need to be braced for seismic activity appropriate for the region.	High
17. Systemwide bit error rates (BER) should not exceed 10^{-6} .	High
18. The microwave systems need to be supported by an adequate orderwire for system site communications and maintenance.	Medium
19. Where appropriate, the analog microwave links need to serve as a backup for the digital microwave network.	Medium
20. The network must support, at a minimum, T1 channel speed through each component and link.	Medium
21. All multiplex channel cards need to be user programmable by field service engineers at remote sites.	Medium

	<u>Priority</u>
22. Dish mounts, stabilizers and mounting brackets need to be hot-dipped galvanized for corrosion protection.	Medium
23. All antennas need to be supplied with covers.	Medium
24. System backup batteries need to be capable of providing reliable service for a minimum of 15 years.	Medium
25. Battery chargers need to be capable of powering the microwave system while simultaneously recharging the backup batteries.	Medium
26. Backup battery recharging times must not exceed 12 hours.	Medium
27. A plan is needed for reconfiguration of paths to support potential future requirements exceeding 6 Mb of throughput.	Medium
28. Modular components need to be used whenever possible for quick and easy repairs.	Low
29. To ensure uninterrupted service, all microwave links must be capable of being monitored while remaining in service.	Low

Wire and Cable

1. Wire and cable infrastructure needs to meet the current and future needs of the County's voice, data and video communications requirements.	High
2. Development of standards and specifications for building wire and cable needed to facilitate installation and maintenance of equipment and services.	High
3. Building wire and cable standards need to address comprehensive installation requirements, including jumper wire termination procedures and jack conductor specifications.	High

- | | | |
|----|---|--------|
| 4. | Building wire and cable plans need to incorporate intelligent closets and easily defined demarcation points for user/vendor and network terminations. | High |
| 5. | Documentation of building and infrastructure cabling and subsequent changes needed to ensure availability of facilities to meet project needs. | High |
| 6. | Facility limitations relating to wire and cable installation, such as environmental hazards and accessibility, need to be documented as part of a Countrywide assessment of owned and leased communications facilities. | High |
| 7. | Backup to landlines supporting essential applications and functions needed to minimize downtime relating to facility disruptions. | High |
| 8. | Connectivity plan for remote LANs needed to help ensure compatibility with proposed network access standards. | Medium |
| 9. | Single provider of wire and cable installation and maintenance needed to facilitate documentation and change management process and heighten accountability. | Medium |

ALTERNATIVES ANALYSIS

Analog Microwave

After carefully reviewing the present analog microwave operations, we examined alternatives for improving the existing system to meet the current and future needs of the simulcast radio backbone. Options for enhancing the analog microwave system, which requires a high level of reliability, fall into two categories:

- Upgrade the Existing Microwave Components to Adequately Support the Simulcast Radio System

-
- Replace the Simulcast Radio Microwave Components With Digital Microwave Components

Upgrade Existing Simulcast Components - The analog microwave system has supported the simulcast radio network and other County systems for nearly 18 years. The system requires a high level of maintenance and represents a weak link in County communications systems due to its lack of redundancy. One alternative to improve the reliability and operation of the system would be to upgrade the analog microwave components supporting the simulcast radio network. This approach would provide reliable new multiplex equipment and hot-standby microwave radios.

The major advantage of this approach is that the entire microwave network supporting the radio system would be analog which would result in a straightforward approach for maintenance and support. Also, equipment that is replaced could be reused to maintain failing microwave components in other less critical paths.

The main disadvantage of this approach is that it would be more costly than migration to digital microwave. Also, the simulcast system would continue to rely on an analog microwave backbone. Analog systems are technically complex and introduce additional maintenance requirements which can adversely affect simulcast radio transmissions. Furthermore, due to the size and complexity of the County's simulcast radio backbone, the microwave backbone would need to be equipped with dynamic test equipment to assist in maintaining the quality of the simulcast audio quality and coverage. The implementation of dynamic test equipment for the analog microwave system requires additional modem equipment at each site within the network which would result in significantly increased costs.

The estimated one-time costs to upgrade seven sites of the existing analog microwave system to support 30 simulcast channels would range from \$2,113,000 to \$2,693,000.

Replacement With Digital Microwave Components - A second alternative for improving the analog microwave system is to replace the critical primary links supporting the simulcast system with digital microwave equipment. The seven microwave paths

which support the simulcast radio sites could be upgraded to digital and interfaced to the remaining analog microwave paths that support less critical sites of the radio network.

A primary advantage of this approach is that it would be less costly than the analog approach. Also, the digital components should provide a much more reliable communications network for simulcast radio. Digital microwave paths require less maintenance and are often serviceable from a single network hub. In addition, channel expansion on a digital network is less expensive than on analog systems, resulting in a substantial cost savings for large microwave installations. As with analog systems, dynamic test equipment would be needed to enhance simulcast radio quality and reduce maintenance efforts. Dynamic test components for digital microwave systems are usually less costly than for analog systems due to the limited equipment requirements at each radio site.

The primary disadvantage of this approach is that it would result in a mixed analog and digital microwave system approach to support the radio network. This would result in more complex training and duplication of some test equipment. The estimated one-time cost to replace the analog simulcast components with digital equipment on the seven primary links to support 30 simulcast channels would range from \$1,513,738 to \$1,795,238. These costs are detailed in Exhibit V-D.

Digital Microwave

The digital microwave system for the County has been in service for six years. The network includes nine paths which have continued to provide reliable service since installation. Most, if not all, of the digital equipment remains state-of-the-art and should provide reliable service for the next five to seven years. However, the digital network has been expanded to maximum channel capacity in several locations. Expansion ability is further limited by a lack of available equipment room space for increasing channel bank capacity.

The following table identifies the current channel bandwidth capacity of the digital microwave network:

<i>Path</i>	<i>Current Channel Bandwidth Capacity</i>
HOJ to Sign Hill	26 Mb
Sign Hill to Hunt	6 Mb
Sign Hill to South San Francisco	6 Mb
HOJ to Bovet	45 Mb
Bovet to County Hospital	45 Mb
HOJ to Harbor	6 Mb
HOJ to East Palo Alto	6 Mb
HOJ to Rolph	26 Mb
Rolph to Hillcrest	26 Mb

To support future voice communication system upgrades, increasing wide-area data network requirements and new video technologies, the County will need to expand capacity on several microwave paths. Specifically, projects involving switch replacement for South San Francisco and San Mateo County General Hospital will likely require additional capacity on the microwave network. In addition, modifications to the digital network at some sites may not be possible until additional room modifications are made to provide necessary equipment space. Building renovations should be coordinated with upgrades to the analog microwave system to ensure adequate expansion.

We have carefully evaluate the existing digital microwave network and have provided cost estimates for the upgrade of seven digital paths. In some cases, existing smaller capacity paths are replaced with new 45Mb paths and, in others, the existing paths are expanded with additional channel cards and modems to meet new capacity requirements. We estimate that the cost for the upgrades and replacements should range between \$1,670,000 and \$2,579,000.

As part of our analysis, we reviewed the cost-effectiveness of utilizing leased T1 lines where an entire microwave path would need to be upgraded. The following table identifies the cost differential between adding a new T1 microwave path, adding a T1 path to an existing microwave link and a lease telephone company T1:

New Microwave Path With T1	\$154,000	to	\$199,000
Add One T1 Path to Existing Microwave	\$5,800	to	\$9,700
Lease Telephone T1 (Annual, No Install)	\$9,800	to	\$10,700

Based on this review, it may be more cost effective to utilize telephone company circuits in cases where there is a minimal requirement for circuits. In cases where there is a requirement for five or more T1 circuits, the payback for utilizing microwave should be in the three- to five-year range.

To accurately assess the capacity requirements for each path, a detailed review of each microwave site must be performed. As part of this review, the County should consider where common paths between the analog microwave system and digital system could be shared. The existing digital paths to Sign Hill and Rolph are also shared by the analog system. Should space be available, the existing digital system could be upgraded with channel banks and modems to accommodate the channels of the analog system. In addition, the current analog paths from the Hall of Justice building to Pise Point could be supported through the existing digital paths which run through Rolph. Should this configuration be appropriate, the County could reduce the digital upgrade costs for the analog microwave network.

Wire and Cable

The San Mateo County infrastructure must be upgraded and standardized to support the current and emerging technologies outlined in this Strategic Plan. The wire and cable plan must support existing voice and data applications and accommodate both Ethernet and Token Ring connectivity, while providing a sound foundation for future technology requirements. We suggest that the County adopt a universal wire and cable distribution system utilizing Level V cable. Each run should comprise two four-pair cables to accommodate both voice and data connectivity. It is important that end-to-end Level V integrity be preserved by meeting specifications for station wire, conductor and jumper wire twists.

A universal wire and cable distribution system enables standard voice and data connectivity for all users, and as a result, facilitates installation of new voice and

data devices. Utilizing two four-pair wires helps ensure the flexibility to accommodate all installation needs without pulling additional cable for each new request. Compared to Level III cable, which is prominent throughout recent County installations, Level V offers maximum future flexibility at minimal additional cost. However, cabling retrofits to meet Level V standards could be impractical or infeasible in some of the County's older facilities. Adopting a universal wire and cable distribution system requires development and maintenance of cable records organized by individual station runs.

RECOMMENDATIONS

Through our analysis of the alternatives and their associated costs and benefits, we have developed what we believe is the best strategic approach for the County of San Mateo to pursue for improving the common infrastructure that supports the voice, data and radio communications systems. The following is a summary of our recommendations.

Microwave

1. ***Upgrade and Improve Analog Simulcast Equipment*** - The analog microwave system is a critical backbone component of the simulcast radio system. The support of this network, SMARTS and BACIS are key to sustaining mutual aid communications in the event of major incidents and disasters. As a result, we believe that each primary path of the analog microwave system should be upgraded to digital hot-standby radio links. Replaced analog equipment should be re-used to maintain the remaining analog paths which support radio and voice systems.
2. ***Expand Channel Capacity Throughout Digital System*** - In order to support the rapidly increasing needs for extended voice and data communication the digital microwave system should be upgraded. Several of the paths within the system are only capable of supporting 6 Mb. We recommend that the County upgrade all primary paths to support at a minimum an additional eight T1s of capacity. This upgrade would include the expansion of existing paths as well as the replacement of others. The proposed configuration of the microwave network to support the radio, voice, and data systems is shown in Exhibit V-C.

3. *Conduct Site and Path Capacity Analysis* - The County should undertake a complete study of the channel capacity requirements at each site for the analog and digital microwave system. After determining the exact requirement for each site, the analog and digital microwave systems should be evaluated to determine whether existing equipment will meet the County's needs. Where economically feasible, the County should consider the use of leased telephone company T1 lines for non-critical systems connections.
4. *Implement Dynamic Synchronization Equipment* - As part of the analog microwave upgrade, the County should implement dynamic test and synchronization components in each primary path of the simulcast microwave system. The purpose of this equipment is to enhance the performance of the simulcast radio system and minimize maintenance expenses and time.
5. *Obtain Documentation on Honeywell Dataplex System* - The switch supporting three-digit microwave dialing is aging, but very reliable. The County should contact Honeywell to obtain move, add, and change documentation and to request contacts in the user community with whom to communicate about potential sources of system support.
6. *Relicense and Upgrade 960 MHz Digital Path* - The weakest link within the digital microwave system is the path to East Palo Alto which operates in the 960 MHz band in a non-redundant mode. To ensure that all critical communications are maintained we recommend that this path be relicensed to a 6 GHz or 10 GHz frequency and that the new path equipment be redundant.

Wire and Cable

1. *Implement Universal Wire and Cable Distribution System* - The County should adopt, as a wiring standard, two four-pair cables meeting end-to-end Level V specifications for all station wire runs. Retrofits should be undertaken in conjunction with expansion and remodeling projects and where feasible based on building construction. Detailed cable records should be developed and maintained.

ESTIMATED COSTS

Microwave

The estimated total one-time costs to upgrade seven paths of the analog microwave backbone should range from \$1,513,738 to \$1,795,238. These costs are detailed in

Exhibit V-D. The estimated one-time costs to expand the digital microwave backbone to support future County needs for voice, data, and imaging systems should range from \$1,670,425 to \$2,579,213. These costs are detailed in Exhibit V-E.

The estimated annual recurring costs to maintain the seven upgraded simulcast microwave paths should range from \$90,824 to \$107,714. The annual recurring costs to maintain the expanded digital microwave backbone should range from \$100,226 to \$154,753.

Wire and Cable

The estimated cost for developing and installing a universal wire and cable plan using Level V cable is \$125 to \$200 per cable run depending on the length, quality, and complexity of the runs. The costs for 200 new cable runs to support the initial phase of the enterprise network are included in the Data Systems section of this report.

IMPLEMENTATION PLAN

The County should begin planning for the implementation of an enhanced digital microwave system and coordinate the specifications for detailed path expansion with the voice and data systems and infrastructure planning processes. Once the exact needs have been determined, the County should develop specifications for the expanded system and select a system through competitive procurement. The implementation of the new microwave infrastructure should be complete by the first quarter of year three. The implementation schedule is shown in Exhibit V-F.

BENEFITS

We believe significant benefits should be derived by San Mateo County as a result of implementing our infrastructure recommendations. Some of these are listed as follows:

Microwave

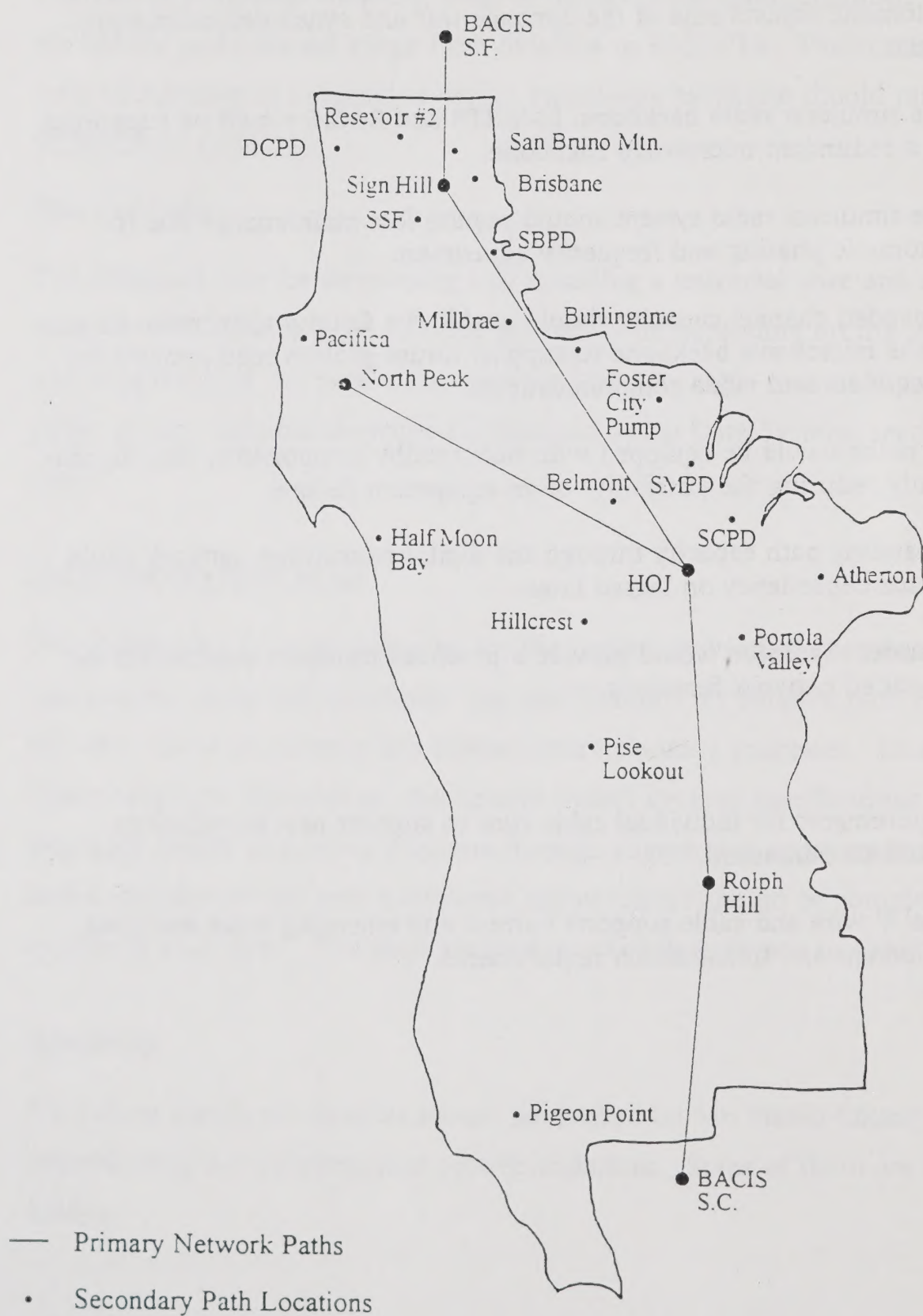
- The County would retain use of many existing system components as part of this approach.
- Radio users would experience improved simulcast radio quality due to automatic adjustments of the dynamic test and synchronization equipment.
- The simulcast radio backbone, SMARTS and BACIS would be supported by a redundant microwave backbone.
- The simulcast radio system should require less maintenance due to automatic phasing and frequency adjustment.
- Expanded channel capacity should enable the County to increase its use of the microwave backbone to support future growth requirements for voice, data and video communications.
- All paths would be equipped with hot-standby components, thus significantly reducing the possibility of an equipment failure.
- Expanding path capacity through the digital microwave network could reduce dependency on leased lines.
- Channel expansion would provide a potential transport mechanism for expanded network functions.

Wire and Cable

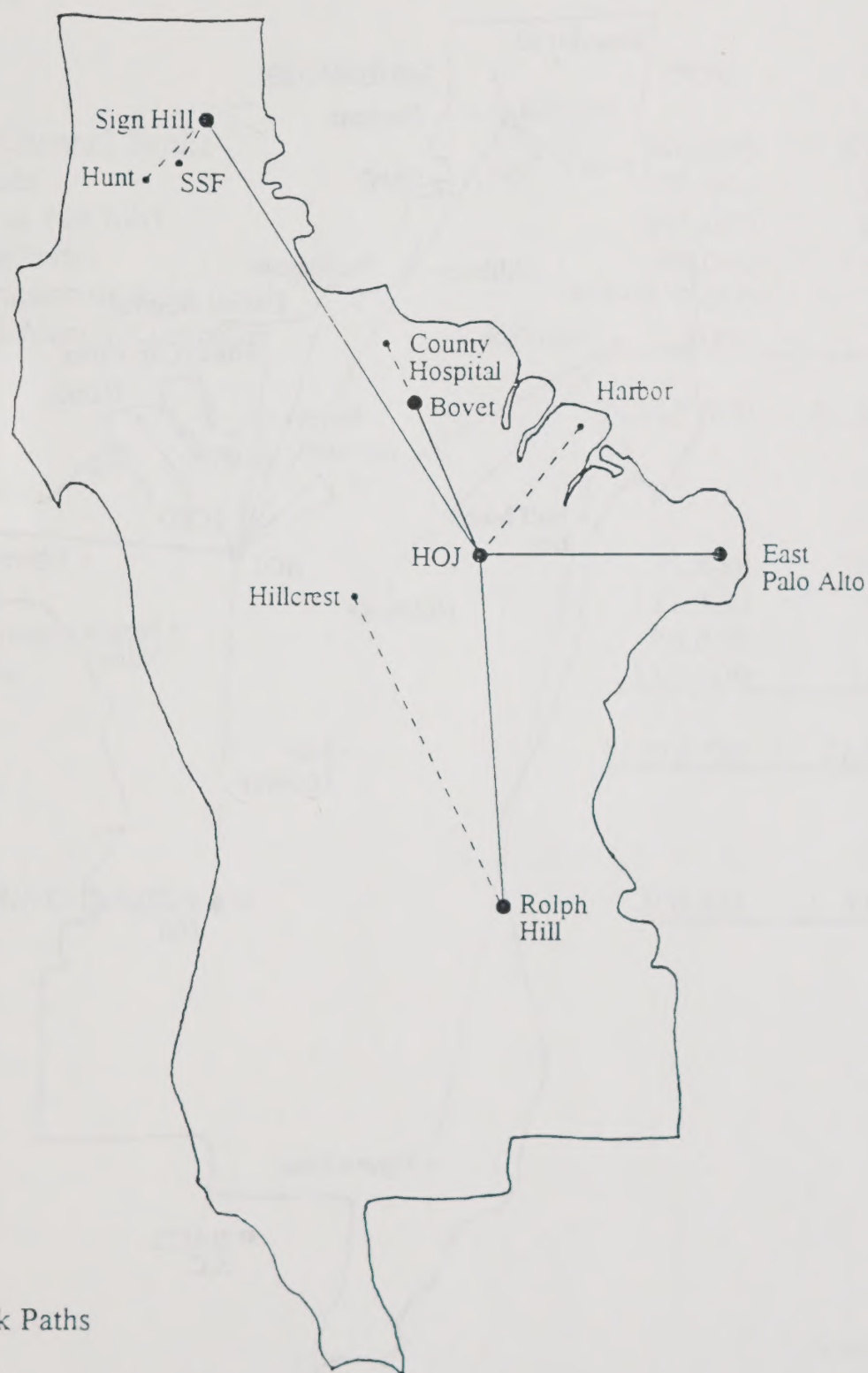
- Requirements for individual cable runs to support new installations should be minimized.
- Level V wire and cable supports current and emerging voice and data equipment and transmission requirements.

COUNTY OF SAN MATEO

Existing Analog Microwave Network



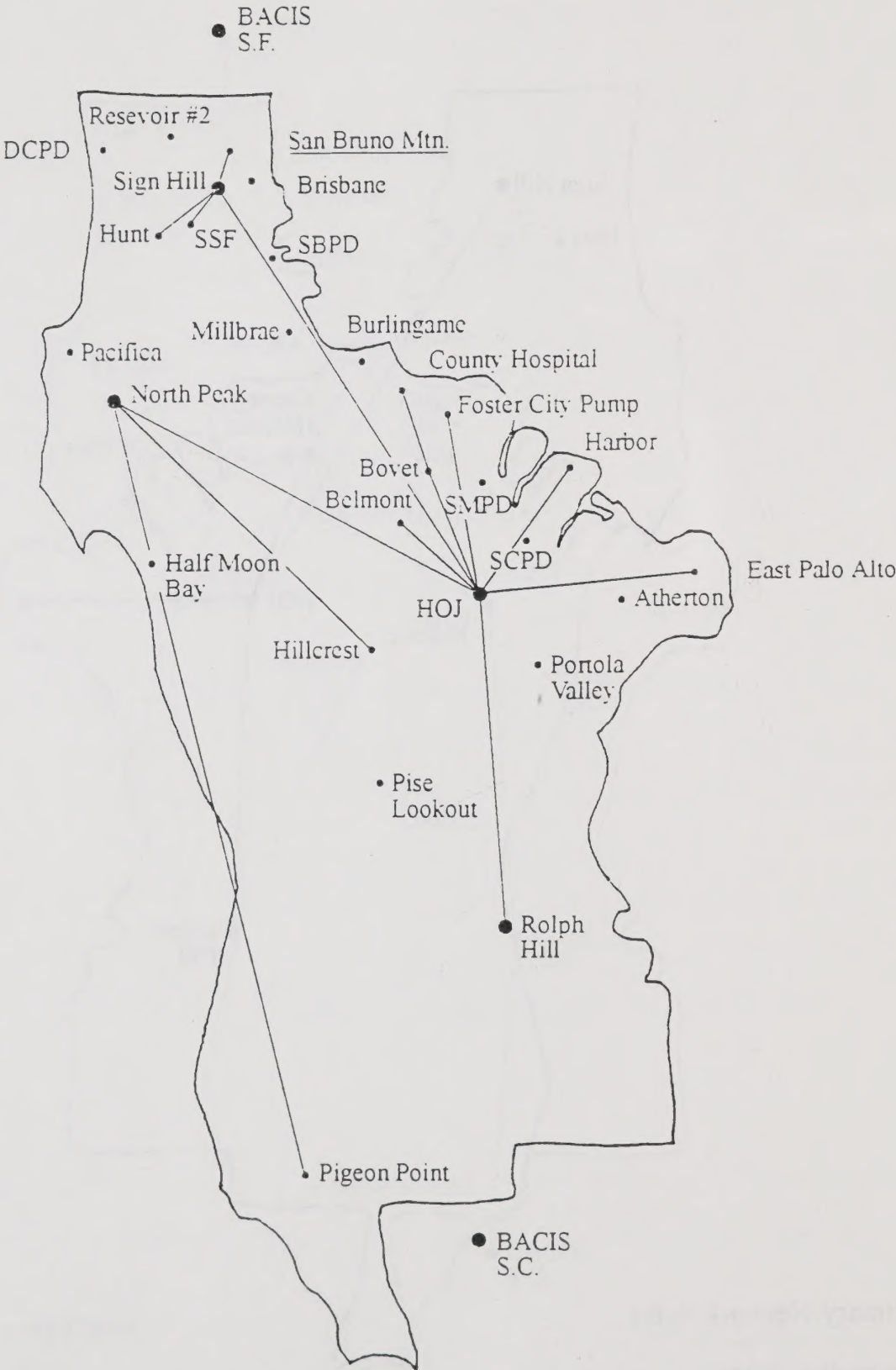
COUNTY OF SAN MATEO
Existing Digital Microwave Network



— Primary Network Paths

--- Secondary Paths

COUNTY OF SAN MATEO
Proposed Microwave Network



CONFIGURATION

- Primary New/Upgrade Digital Network Paths
- Secondary Analog Path Locations

COUNTY OF SAN MATEO
COUNTYWIDE TELECOMMUNICATIONS STRATEGIC PLAN

Estimated Analog Microwave Upgrade Costs

ONE-TIME COSTS

Hardware

Microwave Channel Banks	\$90,000	-	\$104,000
Channel Cards	120,000	-	140,000
Digital Radios (26 Mb)	640,000	-	832,000
Antennas/Batteries	240,000	-	288,000
Dynamic Synchronization Cards	9,000	-	11,000
Phase/Audio Master Controller	12,000	-	16,000

Subtotal \$1,111,000 - \$1,391,000

Other

Sales Tax - 8.25%	91,658	-	114,758
Installation - 10%	111,100	-	139,100
Professional Assistance - 8%	88,880	-	11,280
Contingency - 10%	111,100	-	139,100

TOTAL \$1,513,738 - \$1,795,238

ANNUAL RECURRING COSTS - 6% \$90,824 - \$107,714

COUNTY OF SAN MATEO
COUNTYWIDE TELECOMMUNICATIONS STRATEGIC PLAN

Estimated Digital Microwave Expansion Costs

ONE-TIME

Hardware

Microwave Channel Banks	\$240,000	-	\$396,000
Channel Cards	432,000	-	792,000
Digital Radios	400,000	-	520,000
Antennas/Batteries	150,000	-	180,000
Cross Connections	4,000	-	5,000

Subtotal \$1,226,000 - \$1,893,000

Other

Sales Tax - 8.25%	101,145	-	156,173
Installation - 10%	122,600	-	189,300
Professional Assistance - 8%	98,080	-	151,440
Contingency - 10%	122,600	-	189,300

TOTAL \$1,670,425 - \$2,579,213

ANNUAL RECURRING COSTS - 6% \$100,226 - \$154,753

Notes:

- Assumes 8 T1 channel expansion per path with hot standby digital radios.

COUNTY OF SAN MATEO

INFRASTRUCTURE

Implementation Plan

Exhibit V - F

	Year 1												Year 2				Year 3				Year 4				Year 5			
	1	2	3	4	5	6	7	8	9	10	11	12	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Digital Microwave Upgrade																												
Identify Capacity Needs/ Requirements																												
Develop Specifications																												
Develop RFP																												
Issue RFP to Vendors (Vendors Respond)																												
Evaluate Proposals																												
Select Vendor/Systems																												
FCC Licensing																												
Site Preparation																												
Delivery																												
Installation																												
Testing/Acceptance																												

TABLE OF CONTENTS

The information contained in this document is confidential and its disclosure to unauthorized persons could result in damage to the interests of the Company. This document is intended for the use of the persons named herein and is not to be distributed to other persons without the prior written consent of the Company. The information contained herein is the property of the Company and is to be kept confidential. It is to be used only for the purposes for which it was provided and is not to be disclosed to other persons without the prior written consent of the Company. The information contained herein is to be kept confidential and is not to be disclosed to other persons without the prior written consent of the Company.

The information contained in this document is confidential and its disclosure to unauthorized persons could result in damage to the interests of the Company. This document is intended for the use of the persons named herein and is not to be distributed to other persons without the prior written consent of the Company. The information contained herein is the property of the Company and is to be kept confidential. It is to be used only for the purposes for which it was provided and is not to be disclosed to other persons without the prior written consent of the Company. The information contained herein is to be kept confidential and is not to be disclosed to other persons without the prior written consent of the Company.

SECTION VI

The information contained in this document is confidential and its disclosure to unauthorized persons could result in damage to the interests of the Company. This document is intended for the use of the persons named herein and is not to be distributed to other persons without the prior written consent of the Company. The information contained herein is the property of the Company and is to be kept confidential. It is to be used only for the purposes for which it was provided and is not to be disclosed to other persons without the prior written consent of the Company. The information contained herein is to be kept confidential and is not to be disclosed to other persons without the prior written consent of the Company.

THE WARNER GROUP

The following is a list of the members of the Warner Group:

ORGANIZATION

The information contained in this document is confidential and its disclosure to unauthorized persons could result in damage to the interests of the Company. This document is intended for the use of the persons named herein and is not to be distributed to other persons without the prior written consent of the Company. The information contained herein is the property of the Company and is to be kept confidential. It is to be used only for the purposes for which it was provided and is not to be disclosed to other persons without the prior written consent of the Company. The information contained herein is to be kept confidential and is not to be disclosed to other persons without the prior written consent of the Company.

THE WARNER GROUP

VI - ORGANIZATION

OVERVIEW OF CURRENT ORGANIZATION

The Information Services Department (ISD) is responsible for technology support and development for San Mateo County. This role includes all aspects of information collection and transfer, system maintenance, application development, technology research and user support. The Department strives to assist County organizations in the achievement of their business objectives by providing quality information systems and communications services. ISD's system responsibilities include voice, data, radio and microwave communications and the supporting infrastructure of these systems.

The structure and staffing levels of the Information Services Department have been impacted by recent workforce reductions and realignment of departmental functions. Non-management positions within the Information Services Department are currently being restructured to address changing work requirements and enhance career paths. The Department recognizes the need to align its products and services with the evolving needs of the user community. The functional divisions of ISD are shown in Exhibit VI-A, and Exhibit VI-B depicts the responsibilities of each division of ISD.

EVALUATION OF CURRENT ORGANIZATION

The following is a summary of our organizational findings:

- *ISD Management Team Envisions Shift to Consulting Role* - The management team of the Information Services Department envisions a shift of strategic departmental direction from service provider to consultant. A reliance on contract providers for some traditional ISD development and support activities is anticipated.
- *ISD Plans to Provide User Standards* - A goal of the Information Services Department management team is to develop systems, applications, network and procedural standards to provide users guidance and flexibility.

ty. Through development of standards, ISD hopes to facilitate users' selection and implementation processes.

- *ISD Personnel Must Develop Consulting Skills* - Many ISD staff members are skilled at mainframe application development and support, but have little experience "consulting" to user departments. Some personnel have expressed a concern of the ability of staff to develop the skills necessary to successfully transition to these new roles.
- *Staff Members Perceive Some Technical Weaknesses in Management Team* - Some staff members perceive a lack of technical depth and expertise among the ISD management team. It is perceived that the Management Team discusses strategic utilization of new technology, but does not follow-up with specific migration and implementation plans.
- *LAN Support Team Has Not Grown* - Despite the growing prevalence of local area networks among San Mateo County departments, the ISD team supporting LANs has not increased in size. As a result, the team often works reactively rather than proactively, and has been forced to provide less training and development support to LAN administrators.

NEEDS AND REQUIREMENTS

A well-managed Information Services organization with a clearly defined and communicated strategic direction is essential to instill confidence in user departments. Key organizational needs and requirements relate to employee development and fostering working partnerships with users. Both are important to successful implementations and ongoing utilization of new technologies.

	<u>Priority</u>
1. Realignment of ISD functional structure needed to streamline processes and provide foundation for implementation and support of emerging technologies.	High
2. Clear communication of ISD management team focus and direction needed to alleviate perception that team lacks technical depth and ability to transform concept into action.	High

	<i>Priority</i>
3. ISD/user partnership needed to establish solid foundation for future planning and mutual understanding of business objectives.	High
4. Increased ISD visibility in and accountability for timely completion and follow-up needed to improve user perceptions of ISD capabilities.	High
5. Identification of functional and operational changes relating to redefinition of ISD strategic direction needed to determine requirements for employee training and development.	High
6. Migration plan needed to support ISD employees' transition to new roles.	High
7. Process for user "report cards" needed in all areas of ISD to identify areas of positive performance and those in which users perceive need for improvement.	High
8. Additional resources needed to provide microwave system repair and maintenance support.	High
9. Specific evidence of workload, including tracking of hours worked and tasks completed, needed to determine required staffing levels	High
10. Expanded ISD LAN resources needed to provide enhanced LAN support services to users.	High
11. Formal work request procedure and standard intervals for task completion needed to enable planning and scheduling of ISD workloads.	High

ALTERNATIVES ANALYSIS

To successfully implement and support the technologies and infrastructure envisioned and described throughout this plan, ISD requires a functional organizational structure which complements the emerging strategic focus. While our detailed organizational analysis focuses on the Communications area, we have identified

other functional areas which we believe should be enhanced to facilitate the migration to new systems and networks. Our suggestions are intended to provide a foundation for identifying resource needs and retraining requirements and to suggest the relative positioning of each area within the organization. The structure provides defined roles for development and support of client/server strategies and emphasizes critical user support and planning functions.

The Communications unit will play a key role in the development, installation and maintenance of all Countywide communications infrastructure components and systems. The Communications function should retain responsibilities for the operations for the Radio/Microwave and Telephone Services groups. These groups will be key to the success of the radio, microwave and voice communications systems upgrades recommended in the Strategic Plan. Two new groups should be developed which incorporate the existing Planning/Engineering, LAN Support and Data Communications functions. The first, Network Engineering, should be responsible for the design and implementation of the suggested utility network, as well as for support of current LAN applications and the eventual migration of local area networks into a client/server environment. The second new group, termed Infrastructure, should assume responsibility for development, implementation, and maintenance and documentation of a universal wire and cable scheme for San Mateo County. The groups within the Communications unit should all respond to Customer Support requests for troubleshooting in their respective areas. The Communications function should be positioned in parallel to the Applications, Planning and Support units.

Suggested staffing levels within the Communications division are as follows:

- **Radio/Microwave** - Six technical staff and one working supervisor/project manager are needed to support the radio and microwave infrastructure and to coordinate system enhancements. This staffing level accounts for the identified need to add another microwave technician immediately. It is anticipated that the system upgrades and the implementation of dynamic testing equipment should enable technical staff to work more efficiently and effectively, thereby limiting the need for significant personnel additions.

-
- **Telephone Services** - Four technical staff and one working supervisor/project manager are needed to coordinate ongoing activity and manage upcoming system upgrades and enhancements. The current Telephone Services group is staffed at the suggested resource levels along with two individuals who provide extra assistance as needed on a part-time basis. The current and suggested resource levels should suffice for system and network administration, including move, add and change activity associated with Meridian-1 and Meridian Mail implementations.
 - **Network Engineering** - The Data Services and LAN services groups currently comprise nine positions, including contract and consulting assistance. To complete a detailed network design, implement the network and support the migration of users to client/server computing, we believe this group requires a total of thirteen individuals, including a project manager to oversee the design and migration process.
 - **Wire/Cable Infrastructure** - The suggested wire/cable Infrastructure group does not currently exist. Wire and cable installation and maintenance is performed by Telephone Services technicians or outside vendors. To develop, implement and document a universal wire and cable plan and to coordinate work on this infrastructure with network design and implementation activities, we recommend staffing this group with two technicians and a working supervisor/project manager. Alternatives for this small group include combining it with Telephone Services and utilizing one supervisor/project manager for both groups, or contracting with a wire and cable vendor for installation and support.

In addition to the detailed structure outlined for Communications, we have identified several functional areas which we believe should be integrated into the ISD organization. The suggested functional areas are as follows:

- **Administration** - ISD Administration currently performs County switchboard, accounting and administrative support functions within the Information Services Department. No changes to this group or its current position within the organization are anticipated.
- **Planning** - The Planning function should incorporate the functions now performed by the Business Systems and Technology Research groups. Technology Research should include an expanded end user training function. As the County migrates toward a new technology focus, planning and interaction with user departments must be emphasized. As a result, the Planning unit should be positioned in parallel to the Applications, Support and Communications units to be described below.

- *Applications* - ISD's organization has historically focused on a mainframe environment, with functions, structure and staffing oriented in that direction. The new client/server environment requires an expanded focus. The Applications function should comprise Mainframe and PC/-Other groups. The Mainframe group should be responsible for maintenance and modification of applications that will be kept on the mainframe, and for development of any new applications for which the mainframe is determined to be the optimal platform. The PC/Other group should focus on the development, maintenance and modification of departmental applications residing on platforms other than the mainframe. This group should also support the transition of applications from departmental LANs to network servers as the migration to client/server computing escalates. The Applications function should be positioned in parallel to the Planning, Support and Communications units.
- *Support* - Operations of the Support function should focus on data communications systems and customer support. Groups within the Support function should include the Data Center, Data Entry/Databases, Systems/PCs and Customer Support. Recognizing that computer operations will continue to be required in the client/server environment, the Data Center group should oversee computer room operations. The Data Entry/Databases group should be responsible for relational database development and database administration. Support of minicomputers, network servers and PCs, as well as PC procurement and installation, where appropriate, should be performed by the Systems/PCs group. The Customer Support group should include the Help Desk and serve as the single point of initial contact for all ISD troubleshooting activities. The Support function should be positioned in parallel to the Applications, Planning and Communications units.

RECOMMENDATIONS

The following is a summary of our recommendations associated with improving the Information Services Department organization:

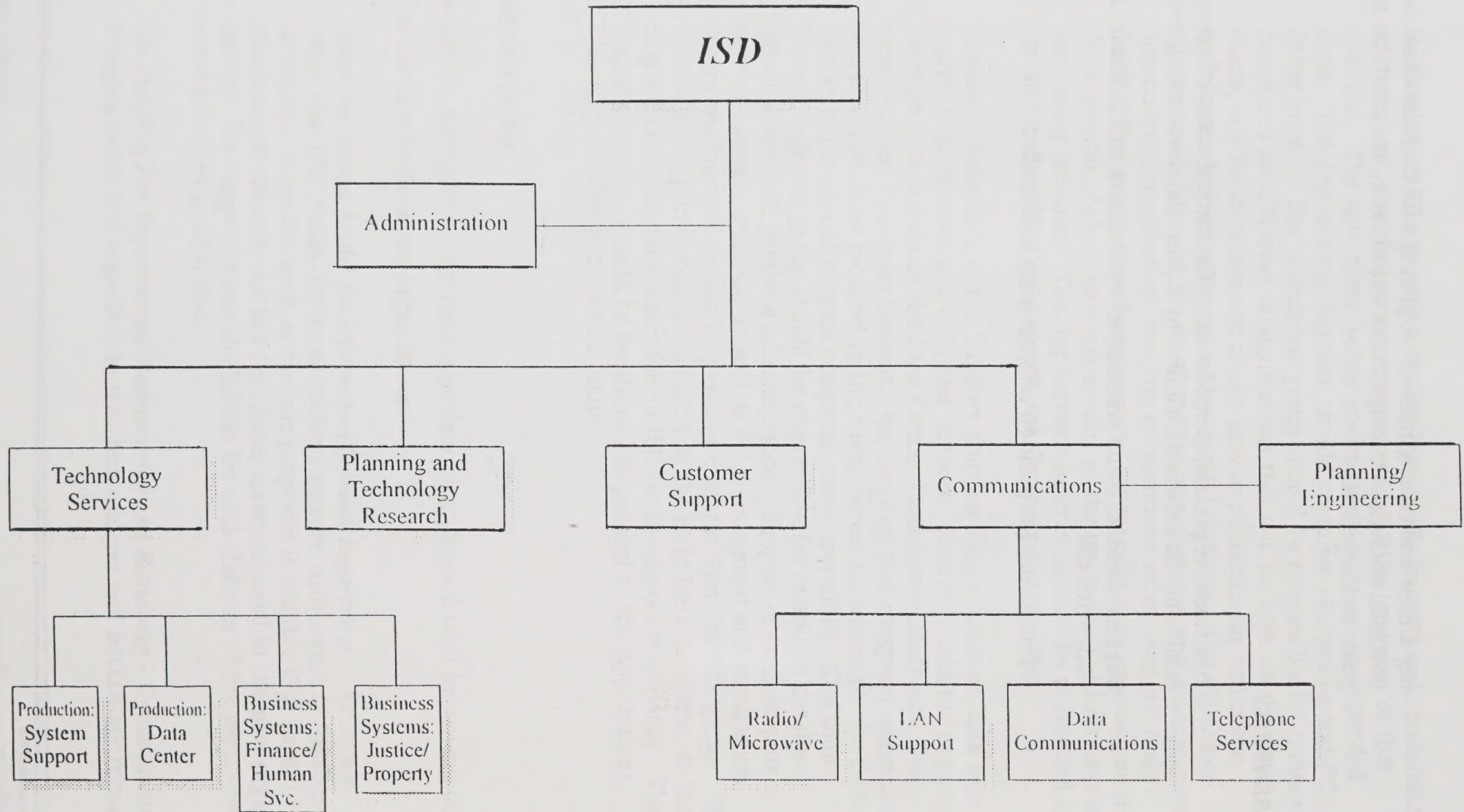
1. *Adopt Functional Model for Information Services Department* - We recommend that ISD realign its organization structure with stated technology directions. A model, such as the one proposed in Exhibit VI-C should be developed to identify the key functional areas required in the new organization. The suggested responsibilities for each division of the department are outlined in Exhibit VI-D.
2. *Develop Plan For Departmental Restructuring and Retraining* - Departmental reorganization and migration to new technologies will necessitate retrain-

ing efforts and reassignments. A plan should be formulated to identify potential personnel reassignments and criteria, and establish training goals and objectives.

BENEFITS

- Functional organization model identifies critical areas of operation and establishes foundation for efficient communications among work groups.
- Suggested model could streamline work efforts and facilitate user interactions with ISD.
- A framework for position restructuring is identified.

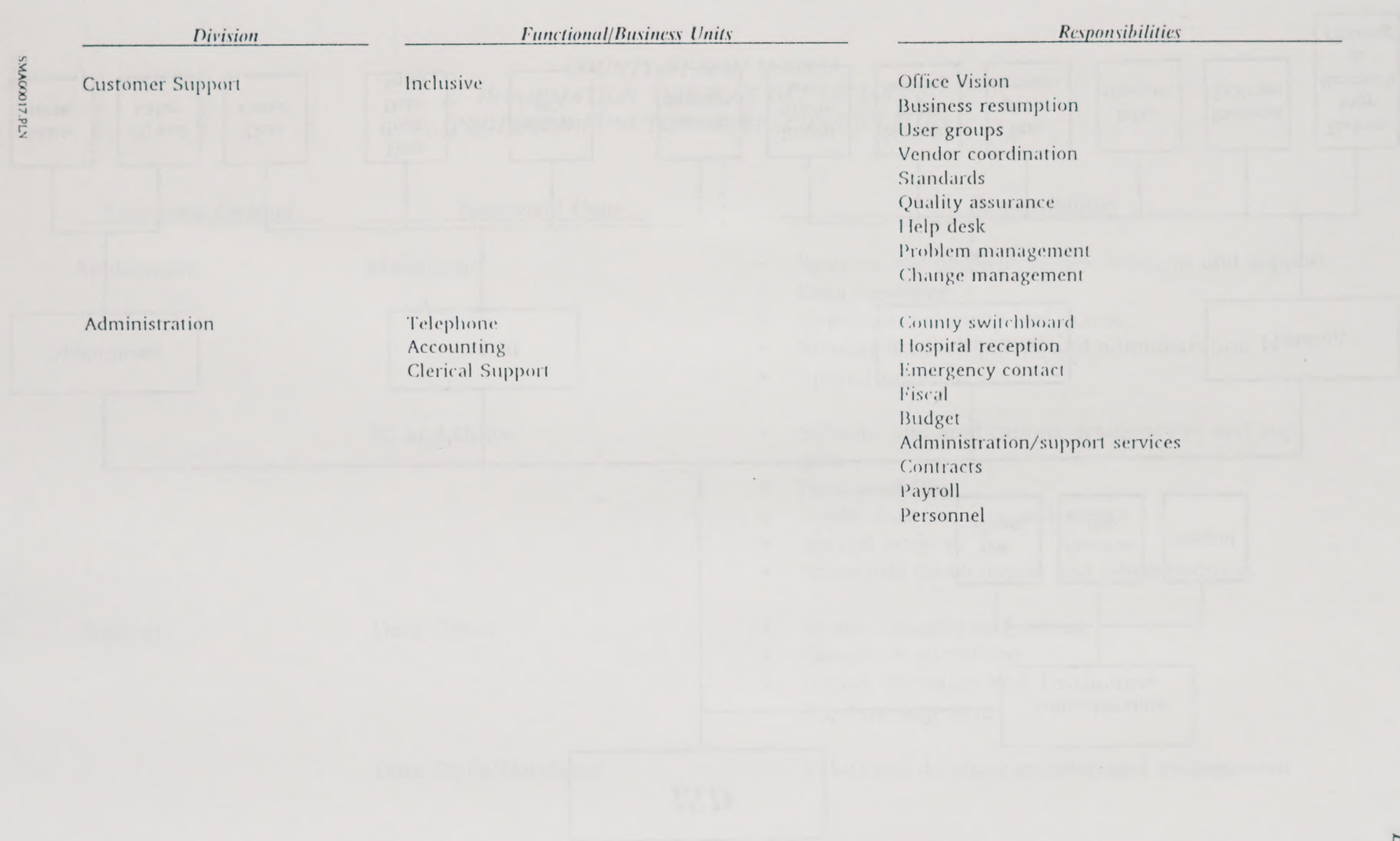
COUNTY OF SAN MATEO
DEPARTMENT OF INFORMATION SERVICES
Existing Functional Organizational Structure



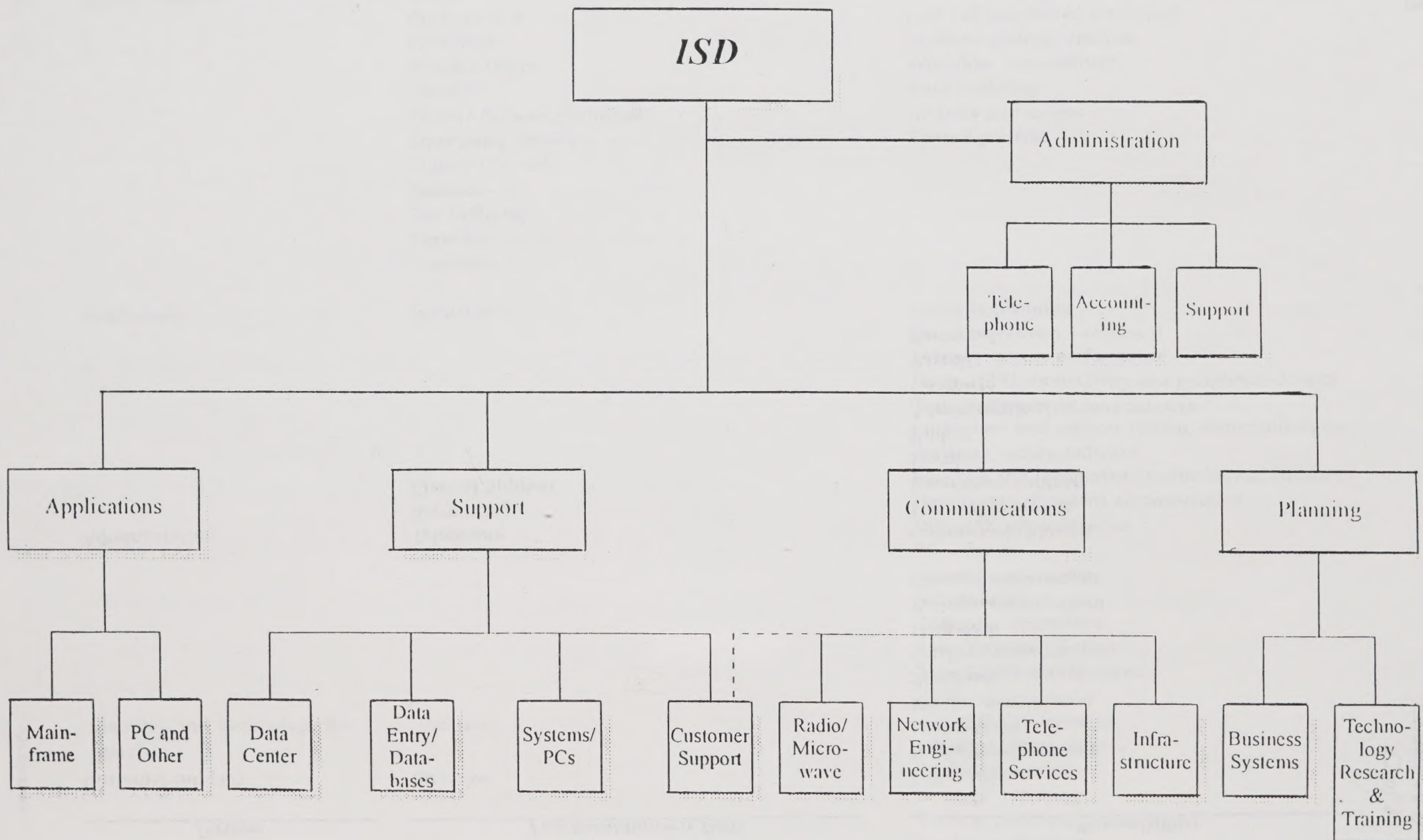
**COUNTY OF SAN MATEO
INFORMATION SERVICES DEPARTMENT
EXISTING DIVISION RESPONSIBILITIES**

<i>Division</i>	<i>Functional/Business Units</i>	<i>Responsibilities</i>
Communications	Planning/Engineering Radio/Microwave LAN Support Data Communications Telephone Services	Support communications infrastructure Maintain radio equipment Coordinate alarm and miscellaneous electronic support Support communications network Install and maintain equipment Design and install LANs Support LANs Assist with network/connectivity planning
Business Systems:		
Finance and Human Services	Public Works Payroll Financial Human Services/Maintenance Human Services/Development Departments: Human Resources Controller Environmental Management Public Works County Manager General Services Clerk of the Board Treasurer Planning Library District Attorney/Family Support	Systems and application development and support (all automated platforms) Business systems analysis Workflow improvement Data modeling Security and access Special projects

<i>Division</i>	<i>Functional/Business Units</i>	<i>Responsibilities</i>
Business Systems:		
Justice/Property	Courts County Clerk Probation Sheriff's Office Coroner District Attorney/Criminal Emergency Services County Counsel Assessor Tax Collector Recorder Controller	Systems and application development and support (all automated platforms) Business systems analysis Workflow improvement Data modeling Security and access Special projects
Production	Inclusive	Capacity planning Disaster recovery - technical Monitor system performance Design CPU connectivity and peripheral devices Tune performance Implement and support system, communications, database, utility software Evaluate and recommend technological advances Data communications administration DEC VAX administration PC software Security and access Scheduling Computer operations Reporting/distribution Tape/DASD management
Planning and Technology Research	Inclusive	ISD staff development County training project Technical writing Strategic planning Tactical planning Product evaluations New product, revenue and pilot programs



COUNTY OF SAN MATEO
DEPARTMENT OF INFORMATION SERVICES
Proposed Functional Organizational Structure



*COUNTY OF SAN MATEO
INFORMATION SERVICES DEPARTMENT
PROPOSED FUNCTIONAL RESPONSIBILITIES*

<u><i>Functional Division</i></u>	<u><i>Functional Units</i></u>	<u><i>Responsibilities</i></u>
Applications	Mainframe	• Systems and application development and support • Data modeling • Application security and access • Standards development and administration • Special projects
	PC and Other	• Systems and applications development and support • Data modeling • Application security and access • Special projects • Standards development and administration
Support	Data Center	• System security and access • Computer operations • Report operation and distribution • Tape management
	Data Entry/Databases	• Relational database creation and management

<u>Functional Division</u>	<u>Functional Units</u>	<u>Responsibilities</u>
Support (Continued)	Systems/PCs	• Systems capacity planning • Hardware and software implementation and management • Disaster recovery • System performance monitoring • Systems connectivity • Standards development and administration • User group support
	Customer Support	• Help desk • Change management • Quality assurance • Business resumption support • Vendor coordination
Communications	Radio/Microwave	• Radio/microwave system administration and maintenance • System upgrades and expansion • Radio equipment maintenance
	Telephone	• Switch maintenance and upgrades • Voice mail enhancements and administration • Voice network and traffic analysis • Equipment adds, moves and changes
	Network Engineering	• Network planning, implementation and support • Network migration • Network performance monitoring • Standards development and administration

<i><u>Functional Division</u></i>	<i><u>Functional Units</u></i>	<i><u>Responsibilities</u></i>
Communications (Continued)	Infrastructure	• Universal wire and cable plan design • Wire and cable installation • Wire and cable retrofits • Records development and maintenance
Planning	Business Systems	• Business systems analysis and planning • Business process re-engineering • Service level agreements • Business resumption planning
	Technology Research and Training	• Product evaluation and documentation • Pilot programs • Technical writing • Internal ISD training • Technology training programs
Administration	Telephone	• County switchboard • Hospital reception • Emergency contact
	Accounting	• Budget • Fiscal administration
	Support	• Administration/support services • Contracts • Payroll • Personnel • User training

SECTION VII

ACTION PLAN

THE WARNER GROUP

This section of the report contains our recommended action plan for the implementation of new and upgraded telecommunications systems for San Mateo County. The plan summarizes the specific implementation schedules for each of the Strategic Plan elements: Voice, Data and Radio systems, and Infrastructure. The detailed implementation schedules are contained in the previous sections of this report.

We believe that the County will be able to achieve its telecommunications objectives in a manageable and cost effective manner by adopting a phased approach over the next five years. This approach should allow for the phased implementation of systems in a priority sequence that establishes a sound framework for the infrastructure and new systems. Also, certain existing system components, such as the telephone hubs, have additional useful life that should be leveraged. In addition, the radio system improvements are scheduled to coincide with new FCC rules and regulations.

The following is our recommended action plan:

1. *Adopt the Strategic Plan* - As a first step, the County should adopt the Telecommunications Strategic Plan to serve as its guide for the development and improvement of its communications systems.
2. *Determine Appropriate Funding and Financing Approach* - Now that the required cost ranges have been determined, the County should determine the most appropriate funding and financing approaches.
3. *Develop Detailed Site and System Requirements* - In order to develop the specifications for the upgraded microwave infrastructure, detailed requirements for each facility and site need to be developed for voice, data, radio and video applications.
4. *Develop Voice Network Hub and Voice Mail Migration Plan* - A detailed migration plan should be developed for the implementation of the new network hub and voice mail systems.

5. *Define Data Applications* - In order to begin the development of the enterprise data network, detailed application and performance requirements should be developed.
6. *Establish Data Communications Standards* - Based on the design of the enterprise network, standards should be developed for the implementation of new networks, operating systems and where appropriate, applications.
7. *Establish Regional Radio Communications Committee* - To begin the planning process for the migration of the County's radio communications systems to new technology, a Regionalized Radio Communications Committee should be formed comprised of user representatives from throughout the County. This will help ensure that interagency communications and coordination is maintained throughout the region.
8. *Procure and Implement Microwave Infrastructure* - Based on the detailed user requirements for the voice, data, radio and video applications, the County should develop detailed specifications and procure the microwave infrastructure.
9. *Design, Procure and Implement Enterprise Data Network* - The detail design of the enterprise data network should be established, including specific user and application requirements as well as performance criteria. In conjunction with the implementation of the infrastructure systems, the first phase of the enterprise data network should be installed. The network should be expanded as the County migrates to client/server technology.
10. *Procure and Implement Radio Communications Upgrades* - The primary components of the existing public safety and EMS radio systems should be replaced.
11. *Procure and Implement Voice Network Hubs and Voice Mail* - Based on the migration plan, the new voice network hubs and voice mail systems should be procured and implemented.
12. *Procure and Implement Mobile Data System* - A mobile data system should be implemented as part of the overall radio communications plans.

The action plan is detailed in Exhibit VII-A. Included is the estimated one-time costs that are expected to be incurred in each of the five years of the strategic plan. By following this action plan, the County should be able to achieve its telecommunications strategic goals in a planned, manageable and cost effective manner.

COUNTY OF SAN MATEO
TELECOMMUNICATIONS STRATEGIC PLAN
Action Plan

	Year 1												Year 2				Year 3				Year 4				Year 5			
	1	2	3	4	5	6	7	8	9	10	11	12	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	Q1	Q2	Q3	Q4
1. Adopt Strategic Plan																												
2. Determine Funding & Financing																												
3. Develop Site & System Requirements																												
4. Develop Voice Hub & Voice Mail Migration Plan																												
5. Assess Data Applications																												
6. Establish Data Standards																												
7. Establish Regional Radio Committee																												
8. Procure & Implement Infrastructure																												
9. Design, Procure & Implement Enterprise Network																												
10. Procure & Implement Radio Upgrades																												
11. Procure & Implement Voice Hubs & Voice Mail																												
12. Procure & Implement Mobile Data																												
Estimated Annual Costs	\$1,665,000 - \$2,770,000												\$6,175,000 - \$7,615,000				\$4,776,000 - \$6,805,000				\$1,656,000 - \$1,799,000							

U.C. BERKELEY LIBRARIES



C101745686

